Final

Smoky Canyon Mine

Pilot Study Work Plan and Sampling and Analysis Plan

Biological Selenium Removal Treatment Technology Fluidized Bed Bioreactor

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LIST OF ACRONYMS

AOC	Administrative Order on Consent
BOD	Biological Oxygen Demand
CCB	Continuing Calibration Blank
CCV	Continuing Calibration Verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMP	Corrugated Metal Pipe
COC	Chain of Custody
COD	Chemical Oxygen Demand
COPCs	Chemicals of Potential Concern
DO	Dissolved Oxygen
DQIs	Data Quality Indicators
DQOs	Data Quality Objectives
EPA	U.S. Environmental Protection Agency
FBR	Fluidized Bed Bioreactor
FS	Feasibility Study
GPD	Gallons per Day
GPM	Gallons per Minute
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operation
ICB	Initial Calibration Blank
ICV	Initial Calibration Verification
IDEQ	Idaho Department of Environmental Quality
IDW	Investigation-Derived Waste
LCS	Laboratory Control Sample
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NF	Nanofiltration
ODAs	Overburden Disposal Areas
O&M	Operation and Maintenance

ORP	Oxidation-Reduction Potential
PLC	Programmable Logic Controller
PSIG	Pounds per Square Inch Gauge
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RO	Reverse Osmosis
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SCADA	Supervisor Control and Data Acquisition
SOP	Standard Operating Procedure
TBD	To Be Determined
TCLP	Toxicity Characteristics Leaching Procedure
TSS	Total Suspended Solids
USFS	U.S. Forest Service
ZVI	Zero-Valent Iron

Acknowledgement

Information on the pilot system, including figures and tables were taken directly from reports prepared by Frontier Water Systems, Salt Lake City, Utah. Pharmer Engineering, Boise, Idaho also provided information and drawings used herein.

1.0 INTRODUCTION

The J.R. Simplot Company (Simplot) owns and operates the Smoky Canyon phosphate mine in southeastern Idaho (Figure 1-1). The Smoky Canyon Mine ("Mine" or "Site") is the subject of a 2009 Administrative Order on Consent (AOC) entered into by the U.S. Forest Service (USFS), U.S. Environmental Protection Agency (EPA), Idaho Department of Environmental Quality (IDEQ) and Simplot. The AOC requires that Simplot conduct a Remedial Investigation (RI) and Feasibility Study (FS) (i.e., RI/FS). In accordance with that AOC, Simplot has investigated the environmental effects of phosphate mining and milling operations at the Site and is in the process of developing remedies to address environmental conditions that represent a risk to human health or the environment.

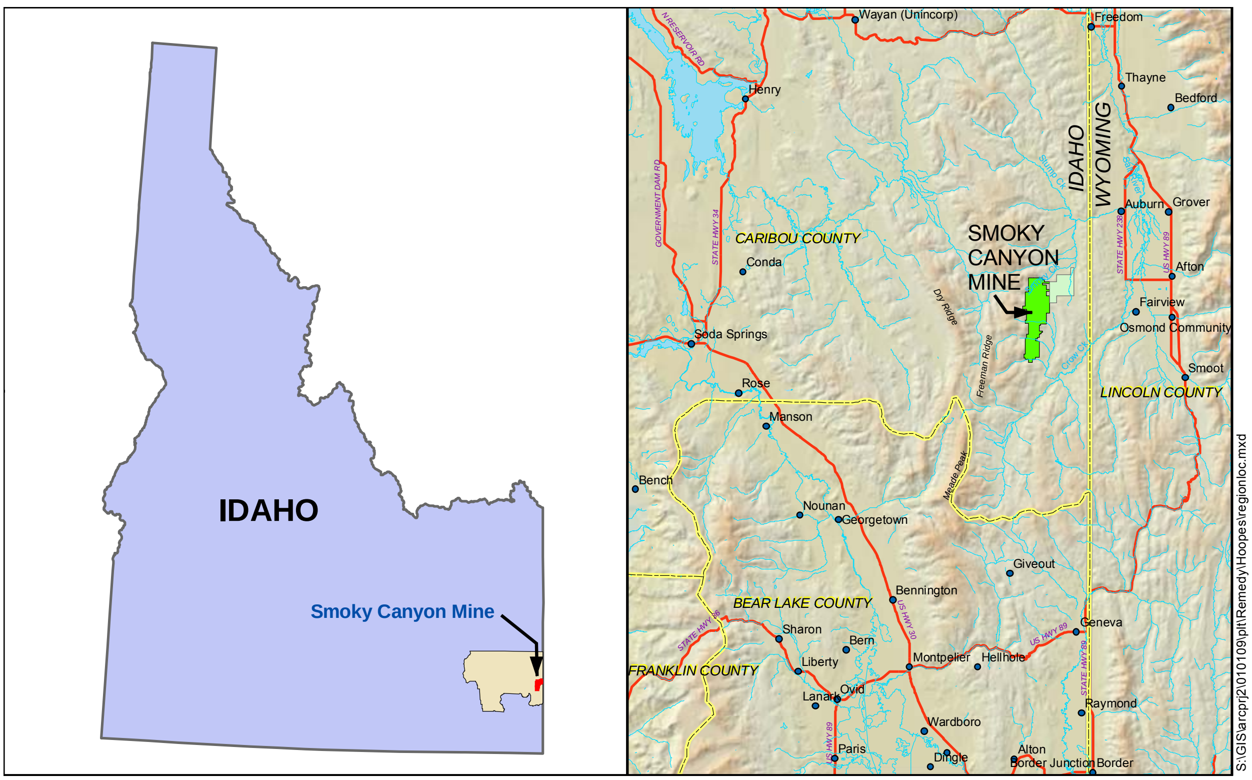

Figure 1-1. Regional Map of Southeast Idaho Showing the Smoky Canyon Mine

Simplot recently submitted the revised draft RI Report (Formation 2014a) that describes the environmental conditions at the Site. One finding was that selenium concentrations in groundwater discharging to the surface at Hoopes Spring and South Fork Sage Creek Springs are above the Idaho surface water quality criterion for protection of aquatic life (the chronic criterion is 0.005 mg/L; IDAPA 58.01.02.210), and exceed Idaho's current acute criterion (0.02 mg/L). The selenium mass load discharged at these two springs is the primary source of selenium to surface waters in the lower Sage Creek drainage. The Site sources of selenium to the springs are overburden materials, removed during active mining to access the underlying phosphate ore. The primary sources of selenium and other chemicals of potential concern (COPCs) within the overburden materials are the sulfides and organic matter present in the Mudstone and Middle Waste Shale from the Meade Peak Member. The overburden materials have been used to backfill pits or have been placed in external overburden disposal areas (ODAs). Water infiltrating through the overburden material mobilizes selenium and other COPCs. A portion of that water migrates to the Wells Formation aquifer. In the south portion of the Site, all affected Wells Formation groundwater discharges at Hoopes Spring and South Fork Sage Creek Springs.

Reducing the selenium mass transport to Sage Creek via Hoopes Spring and/or South Fork Sage Creek Springs is of highest priority for both Simplot and the USFS because reduction of the selenium mass load associated with the springs will provide the greatest improvement in surface water quality within the lower Sage Creek drainage. The target reductions in selenium concentrations will ultimately depend on final remedial action objectives established for the Site (e.g., Idaho surface water quality standard, or a Site-specific standard).

As discussed in the May 2014 addendum to the Surface Water Treatability Study Technical Memorandum (Formation 2014b), if the technology is demonstrated by the 250 gallons per minute (gpm) system described herein, Simplot is committed to increase the treatment capacity of the pilot system to the 1,000 gpm to 2,000 gpm range in 2015-2016. As shown in Attachment 3 to that document, current estimates are that between 2,000 and 4,000 gpm would require treatment in order to reduce selenium concentrations to below 0.005 mg/L immediately downstream of Hoopes Spring and South Fork Sage Creek Springs (2,600 to 3,100 gpm from Hoopes Spring and 400 to 850 gpm for South Fork Sage Creek, depending on the assumptions made).

1.1 Pilot Treatability Studies

Analyses presented in the RI (Formation 2014a) indicate that elevated selenium concentrations will persist at the springs over a period of decades unless remedial actions are implemented. The primary remedial actions expected to be evaluated in the FS are source controls (additional low permeability covers on the ODAs to reduce infiltration) and water treatment at the springs and potentially at ODA seeps.

The ODA seeps represent relatively high selenium (greater than 1 mg/L) and low flow (<40 gpm) treatment candidates. All of the seeps at the Site infiltrate into the ground before reaching nearby streams, although some of the seep water may migrate to the streams via groundwater transport. Treated seep water would not necessarily be discharged to regulated surface water flow systems supporting aquatic life.

Hoopes Spring and South Fork Sage Creek Springs represent relatively low-selenium-concentration (i.e., <0.1 mg/L), high-flow treatment (i.e., >200 gpm) candidates. At both of these springs complexes, treated water would be returned to surface water flow systems that support aquatic life. Effluent from any treatment process at the springs will therefore need to meet the rigorous water quality requirements associated with a cold water fishery (e.g., dissolved oxygen, temperature, etc.). Depending upon the treatment technology, additional polishing/conditioning of the effluent may be required prior to discharge to the creek.

In the early stages of the RI/FS, Simplot evaluated numerous available water-treatment technologies for selenium removal and identified candidate technologies most suitable to implement at the Smoky Canyon Mine (NewFields 2009). These candidate technologies included:

- Traditional high-pressure reverse osmosis (RO);
- Iron-coprecipitation;
- Biological selenium reduction – active treatment systems;
- Zero-valent iron (ZVI);
- Nanofiltration (NF) and/or low-pressure RO;
- Biological selenium reduction – passive treatment systems; and
- Constructed wetlands.

To evaluate the performance of technologies with the highest potential for use as remedial actions at the Site, the following pilot studies have been implemented:

- 2009 – GE ABMet® active, anoxic/anaerobic, biological process – DS-7 seep and also at the nearby Conda Mine Site;
- 2009 – ZVI technology – South Fork Sage Creek;
- 2010 – reverse osmosis – Hoopes Spring; and
- 2013 (ongoing) - semi-passive biological treatment technology – DS-7 seep.

These are discussed in more detail below.

1.1.1 Biological Selenium Reduction

The first technology placed at a seep (FD-1) at the Conda Mine in summer 2009 was a fixed-film, plug-flow bioreactor (“ABMet® system”) using naturally occurring anoxic bacteria to reduce selenium concentrations by precipitating elemental selenium from solution. Influent selenium concentrations were between 0.1 and 0.4 mg/L and a portion of the seep flow was treated by the pilot unit (1-3 gpm). Selenium concentrations were significantly reduced by the treatment system to levels consistently below the 0.005 mg/L surface water standard. The results showed this system was highly effective for selenium removal (Formation 2010a).

The same bioreactor unit used at Conda was redeployed in the fall of 2009 to a low volume seep (DS-7) at the Site that had a typical selenium concentration of 3 to 5 mg/L. A portion of the seep flow was treated by the pilot unit (1-2 gpm). Selenium reduction from the water influent was greater than 99 percent, with selenium concentration in the effluent consistently below the 0.005 mg/L surface water standard. The results from this pilot study at the Site showed an even greater effectiveness, considering that the influent selenium concentration was an order of magnitude higher than the previous test of the same technology at Conda. The pilot tests found that additional treatment of the effluent (oxidation) may be required to allow for discharge to surface water systems supporting aquatic life.

The ABMet® system is classified as an "active" treatment system due to the pH control, oxidation-reduction potential (ORP) control, temperature control, pretreatment filtration that requires frequent backwashing, and degassing of the bioreactors that requires frequent backwashing as well as containment of the released biomass (CH2M Hill 2010). The ABMet® system also requires power, infrastructure, and full-time operators.

A semi-passive biological selenium reduction pilot study was evaluated at the Site in 2001 by the University of Idaho. This pilot study treated a portion of the seep water from DS-7 using a buried bioreactor and by amending the influent with cheese whey, compost, and zero-valent iron to establish and maintain the appropriate environmental conditions within the bioreactor. The pilot system operated for approximately 7 months and achieved selenium removal efficiency between 72 and 97 percent (Moller 2002). This pilot unit was refitted and is being used for the on-going semi-passive treatment pilot study at DS-7 (Formation 2011a). Data from this recent pilot study indicate selenium retention in the range of 60 to 75 percent. The study will be completed in 2015 or 2016 depending on performance evaluations and data needs.

1.1.2 Zero-Valent Iron

The second technology tested at the Site was a zero-valent iron (ZVI) system placed at the South Fork Sage Creek Springs complex in the late summer/early fall of 2009. Influent selenium concentrations from the springs were in the 0.035 to 0.050 mg/L range. The 24-gpm system was designed to be passive, with little to no manual labor or energy input. However, through experience with this treatment pilot, we learned that the system was hardly passive and needed vigilant physical inspections in order to maintain continuous operation. Selenium reduction averaged 40 to 50 percent. This study demonstrated that the technology would not be effective at consistently reducing selenium concentrations to below the 0.005 mg/L surface water standard (Formation 2012).

1.1.3 Reverse Osmosis

The third selenium reduction technology tested at the Site was a low-pressure RO unit at Hoopes Spring (Formation 2011b). The purpose of this treatability study was to investigate the feasibility of concentrating selenium from the spring to produce a concentrate stream that could be routed to an additional treatment system in future applications. The selenium concentration in the spring water influent was 0.030 to 0.050 mg/L during the study. Selenium in the "concentrate", produced by the RO unit, ranged from 0.140 mg/L to nearly 0.200 mg/L. For comparison, selenium and other COPCs in the "concentrate" were at lower concentrations than the influent to the DS-7 ABMet® pilot study. Selenium concentration in the "permeate" (effluent) from the RO unit was effectively non-detect. The unit was capable of treating approximately 25 gpm, with the concentrate comprising 5 gpm and the clean permeate being the remaining 20 gpm. As part of the pilot test operation, the concentrate and permeate were recombined and routed back to the original point of influent capture. The results of the treatability study showed the system was highly effective at separating and concentrating the selenium. Thus, concentration of selenium for subsequent treatment using a lower flow-rate system was proved feasible by RO technology.

1.1.4 Summary

The major findings from the above studies are as follows:

- Passive treatment of spring discharges by ZVI technology is not effective in meeting the selenium standard in surface water.
- Concentration of relatively low-selenium concentration spring water by RO is a viable option as an initial step in a treatment system.
- Active treatment by biological reduction is effective and can meet the selenium standard in surface water. Effluent polishing would be necessary to discharge into cold water fishery streams.
- Passive and semi-passive biological reduction treatment may be an option for seeps, which do not discharge into surface waters, and where significant removal of selenium (rather than meeting the surface water standard) may be an appropriate goal.

1.2 Purpose of the Pilot Study

Early generation biological systems for selenium removal such as ABMet® were based on conventional fixed bed bioreactor design. Fixed bed bioreactors are essentially down-flow, submerged filters that are fed by gravity. As described above, the technology has been shown to be effective at creating the conditions necessary for selenium reduction if given adequate contact time in the bioreactor. However, due to gas retention and slow hydraulic loading rates, these systems tend to be relatively large and can require expensive infrastructure to construct.

Fixed bed bioreactors also generate relatively large backwash volumes laden with concentrated selenium, which must be stored until treatment or disposal.

A developing approach is the utilization of Fluidized Bed Bioreactors (FBRs) for selenium treatment. Historically, FBRs have been successfully employed for other oxyanions such as perchlorate and nitrate, which do not create a solid precipitate as a byproduct. The FBR configuration shows promise for higher kinetics in a smaller footprint; however, when applied to selenium removal, the FBR has inherent process challenges including particulate selenium retention and residuals management, both of which will impact the effluent water quality in regards to total (unfiltered) selenium, organics (BOD/COD), and total suspended solids (TSS). The performance of the filtration operation will require evaluation in the Pilot Study.

This Pilot Study Work Plan describes the procedures for conducting a study of FBR active biological treatment using water collected from South Fork Sage Creek Springs and from Hoopes Spring. The Pilot Study is designed to provide additional information to support development and evaluation of remedial alternatives in the FS. In terms of the 1992 *EPA Guidance for Conducting Treatability Studies Under CERCLA*, this is a "remedy screening" treatability test.[1] Although the treatability test is being conducted primarily to screen technologies for further evaluation in the FS, the test will provide reduction of selenium concentrations in the lower Sage Creek watershed in the short-term.

1.3 Work Plan Organization

This document is comprised of eight sections, organized as follows:

- **Section 1.0 – Introduction:** a general description of the purpose of the Pilot Study.
- **Section 2.0 – Supporting Information:** a summary of Site information relevant to the Pilot Study activities and an overview of the FBR module.
- **Section 3.0 – Pilot Study Design:** describes the various elements of the Pilot Study.
- **Section 4.0 – Data Quality Objectives:** describes the types and quality of data needed to support the study.
- **Section 5.0 – Roles and Responsibilities:** summarizes the roles and responsibilities.
- **Section 6.0 – Sampling and Analysis Plan:** describes the sample collection, field measurement, quality assurance and quality control, and related data review and documentation procedures.

[1] EPA, 1992, p. 10, "During remedy screening, a single indicator contaminant is often monitored to determine whether a reduction in toxicity, mobility, or volume is occurring."

- **Section 7.0 – Data Analysis and Reporting:** describes the evaluation and reporting of the data.
- **Section 8.0 – References:** presents a summary of the referenced documentation.

2.0 SUPPORTING INFORMATION

This section provides Site background information relevant to the Pilot Study activities, an overview of the FBR module, and specific objectives for the Pilot Study.

2.1 Springs Setting and Water Quality

Hoopes Spring and South Fork Sage Creek Springs are located along the west side of Sage Valley, and less than one-quarter mile east-southeast of Panel E of the Smoky Canyon Mine (Figure 2-1).

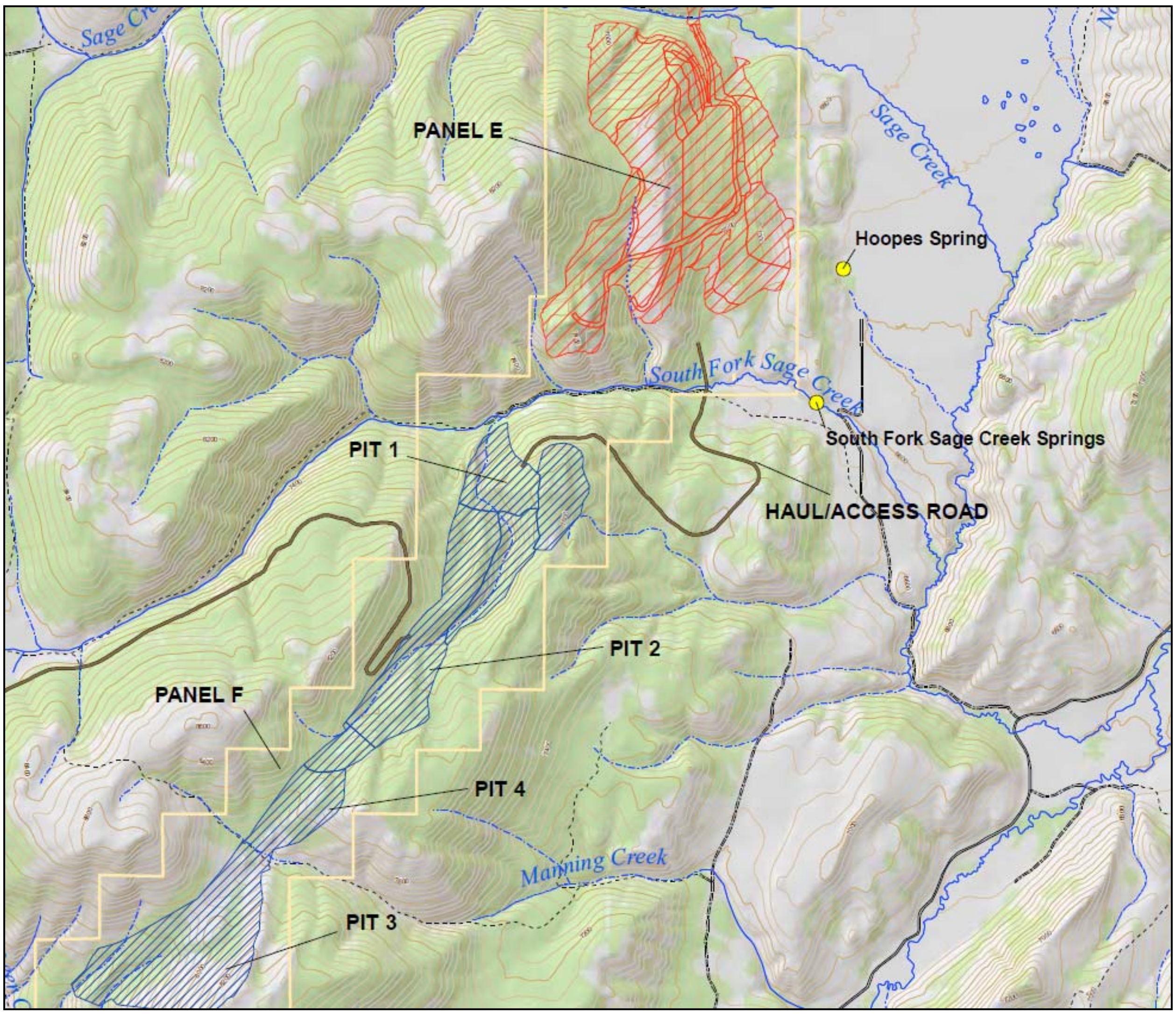

Figure 2-1. South Fork Sage Creek Springs and Hoopes Spring Setting

The springs discharge groundwater from the Wells Formation aquifer. This aquifer is comprised of mainly limestone and sandstone with a complex network of faulting, fracturing, and solution voids that can act as conduits for groundwater flow. The groundwater within the Wells Formation aquifer consists of both regional recharge and local recharge (Mayo et. al. 1985). Local recharge that has come in contact with seleniferous mine overburden from the Smoky Canyon Mine discharges selenium at Hoopes Spring and South Fork Sage Creek Springs (Formation 2014a).

2.1.1 South Fork Sage Creek Springs

This section provides a description of the physical layout and water quality measurements at the South Fork Sage Creek Springs.

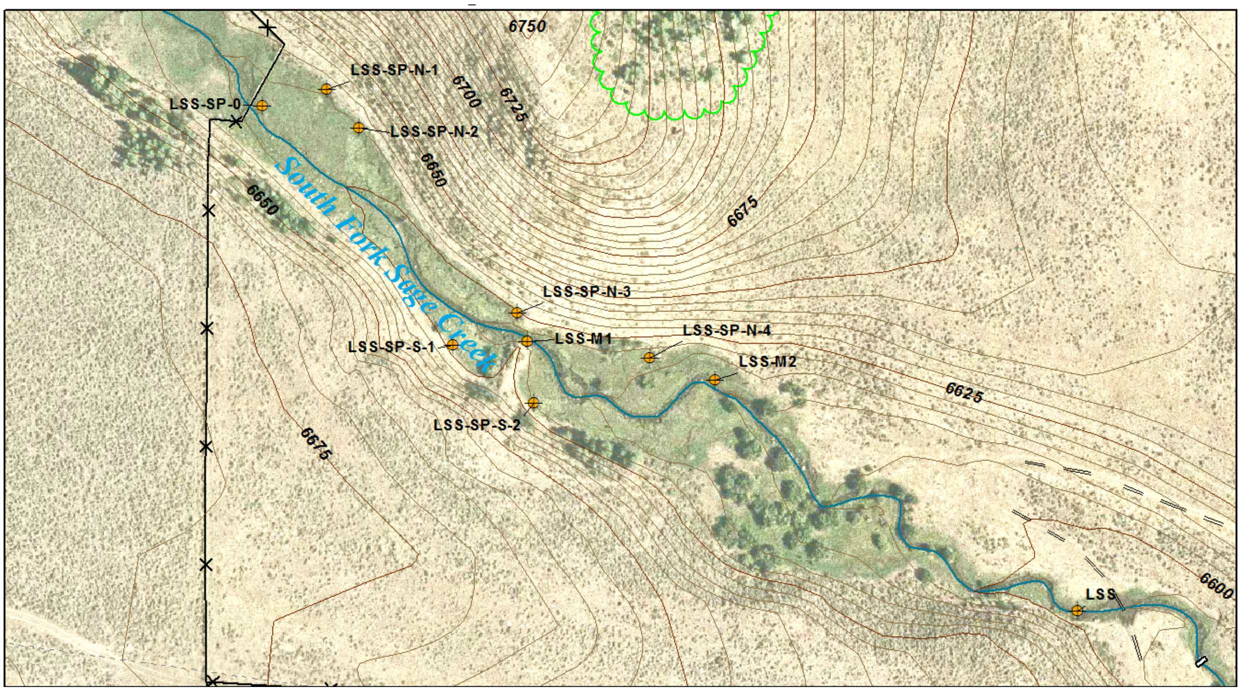

Figure 2-2. South Fork Sage Creek Springs

Groundwater discharges from the South Fork Sage Creek Springs directly to the creek from both its north and south banks (Figure 2-2). Upper South Fork Sage Creek is a losing stream where it flows over outcrops of Wells Formation bedrock and, during most of the year, the area upstream of the springs is dry. During high-flow conditions water does reach the springs from Upper South Fork Sage Creek providing dilution of selenium concentrations. The total spring discharge to South Fork Sage Creek is estimated to be relatively steady in the range of 2,130 gpm (Formation 2014a). The spring water discharging to the creek is the primary source of the selenium mass load to South Fork Sage Creek. Selenium concentrations measured from 2007 to 2013 at multiple locations within the South Fork Sage Creek Springs ranged from 0.0002 mg/L to 0.083 mg/L. There is considerable variability in the selenium concentration of spring water by location. Appendix D presents the full analytical results from the November 2013 sampling event. Typically the spring water discharging from the south side of the creek channel has lower selenium concentrations than that discharging from the north side. The highest concentrations have been observed at monitoring stations on the north side of the creek channel. Concentrations at stations LSS-SP-N3 and LSS-SP-N4 were historically the highest; however, in 2009 several of the north side springs were captured in a single drain to feed the Liberty Pilot Plant (Formation 2012). Since that time, the combined sample station LSS-SP-N has had the highest total selenium concentrations ranging from 0.0322 mg/L to 0.832 mg/L (Table 2-1). Recent observations indicate that the flow rate from the single drain is on the order of 125 gpm. Selenium concentrations in South Fork Sage Creek at the monitoring station known as LSS, below the springs, ranged from 0.0140 mg/L to 0.0242 mg/L in 2013.

Table 2-1. South Fork Sage Creek Total Selenium Concentration Ranges (mg/L)

Location	Date Range	Number of Samples	Number of Detects	Detection Frequency	Minimum	Maximum	Average
LSS	2000 - 2013	82	79	96%	0.00068	**0.0215**	**0.00936**
LSS-SP0	2007 - 2012	58	57	98%	0.00024	0.0024	0.00123
LSS-SP-N	2009 - 2013	31	31	100%	**0.0322**	**0.0826**	**0.0575**
LSS-SP-N1	2007 - 2012	18	17	94%	0.0011	0.0029	0.00227
LSS-SP-N2	2007 - 2012	18	18	100%	0.0029	**0.0108**	**0.00591**
LSS-SP-N3	2007 - 2009	23	23	100%	**0.0151**	**0.0389**	**0.0264**
LSS-SP-N4	2007 - 2009	23	23	100%	**0.0126**	**0.0368**	**0.0232**
LSS-SP-S1	2007 - 2012	50	50	100%	0.0012	**0.0078**	0.00439
LSS-SP-S2	2007 - 2012	50	49	98%	0.00099	0.0035	0.00151

Notes:
Shaded values exceed the surface water standard of 0.005 mg/L.

Selenium concentrations have been increasing in the springs discharge in recent years and selenium is the only COPC to exceed water quality criteria and other benchmark values in South Fork Sage Creek Springs water (Formation 2014a).

Selenium concentrations within the discrete springs vary both seasonally and spatially. Seasonally, the annual maximum selenium concentration typically occurs in late-summer (September) which coincides with the annual maximum Wells Formation groundwater elevation. Spatially, the northern area of the springs has the highest selenium concentrations while the middle and southern areas have similar and relatively lower selenium concentrations.

2.1.2 Hoopes Spring

This section provides a description of the physical layout and water quality measurements at Hoopes Spring.

Hoopes Spring is located along the west side of Sage Valley between Sage Creek and South Fork Sage Creek, and less than one-quarter mile east of Panel E of the Smoky Canyon Mine (Figure 2-1). Similar to South Fork Sage Creek Springs, Hoopes Spring drains groundwater from the Wells Formation aquifer. Local recharge that has come in contact with seleniferous mine overburden from the Smoky Canyon Mine is the primary source of selenium at Hoopes Spring.

Figure 2-3. Hoopes Spring Complex

Hoopes Spring consists of a network of discrete springs that all discharge Wells Formation aquifer groundwater. There are four primary springs sample locations (HS-A1, HS-A2, HS-C1, and HS) and numerous secondary springs within the Hoopes Spring Complex (Figure 2-3). Flow measurements have been made routinely on the middle primary spring (HS) and at the mouth of the Hoopes Spring drainage (HS-3) just before it meets Sage Creek. From 2010 to 2013, the flow rate at HS varied from approximately 760 gpm to 1,900 gpm with an average of 1,200 gpm. There was no pattern of seasonal variability in flow observed at HS. From 2010 to 2013, the flow rate at HS-3 varied from approximately 2,800 gpm to 5,800 gpm with an average of 3,700 gpm. Flows measured at HS-3 best represent the combined flow from the multiple discharge points that comprise Hoopes Spring.

A summary of total selenium concentrations at Hoopes Spring is provided in Table 2-2. Data for other COPCs are presented in the revised draft RI Report (Formation 2014a). Selenium is the only COPC that regularly exceeded relevant water quality criteria. Dissolved oxygen is typically in the range of 6.5-9.0 mg/L, but it has been measured below 6 mg/L on occasion.

Table 2-2. Hoopes Spring Complex Total Selenium Concentration Ranges (mg/L)

Location	Date Range	Number of Samples	Number of Detects	Detection Frequency	Minimum	Maximum	Average
HS	2000 - 2013	88	88	100%	0.003	**0.0897**	**0.0394**
HS-A1	2006 - 2013	46	46	100%	**0.0079**	**0.0317**	**0.0179**
HS-A2	2006 - 2013	46	46	100%	**0.0067**	**0.0283**	**0.0151**
HS-C1	2006 - 2013	47	47	100%	**0.0095**	**0.0993**	**0.0558**

Notes:
Shaded values exceed the water quality standard of 0.005 mg/L.

Seasonally, the annual maximum selenium concentration typically occurs in early fall (September) which coincides with the annual maximum Wells Formation groundwater elevation. Appendix D presents the full analytical results from the November 2013 sampling event.

As part of the RI, 20 discrete locations of groundwater discharge within the Hoopes Spring complex were delineated and sampled. The purpose of this delineation was to identify specific discrete discharge locations with elevated selenium concentrations and to estimate the proportion of the total spring discharge with elevated selenium (Formation 2014a). Spatially, the northern area of the springs has the lowest selenium concentrations while the middle and southern areas have similar and relatively higher selenium concentrations.

2.2 Pilot System Considerations

Simplot has proposed a two year plan for testing this water treatment technology (Simplot 2014). For the first year (2014) an approximately 200-250 gpm pilot treatment system will be constructed at Hoopes Spring. The 2014 system will consist of a single FBR unit, and will treat a comingled flow of South Fork Sage Creek and Hoopes Spring water. If the technology is proven based on the 2014 operation, then a RO unit will be added to the system in 2015, increasing the capacity of the treatment system to 1,000 gpm (or higher). Simplot will also evaluate the addition of a second RO/FBR treatment train in 2015-2016 that would increase the capacity to 2,000 gpm. The pilot plant will be operated year-round for several years to gather long-term performance data.

It is estimated that the pilot system will be brought on line in fall 2014 and will operate through the winter. This will require significant infrastructure to protect the system from cold weather conditions and allow worker access for operation and maintenance. The 2015-2016 additions to the system are expected to include a RO unit and possibly a second RO/FBR treatment train to increase the treatment flow to 1,000 gpm or 2,000 gpm, respectively. The RO system would pretreat water prior to entering the FBR system. Based on the results of the previous RO pilot study, it is expected that a 1,000 gpm RO system will provide 250 gpm for treatment in the FBR system. The pilot system will be constructed near Hoopes Spring, where there is more available space for a larger footprint.

The drain that was developed for the Liberty Pilot system (see Section 1.1.2) is estimated to be currently producing around 125 gpm. This water contains the highest selenium concentrations at South Fork Sage Creek Springs. While it may be possible to further develop the drain to produce 250 gpm, it is possible the additional flow would contain lower selenium concentrations and therefore would dilute the Pilot Study influent. Simplot wants to treat the

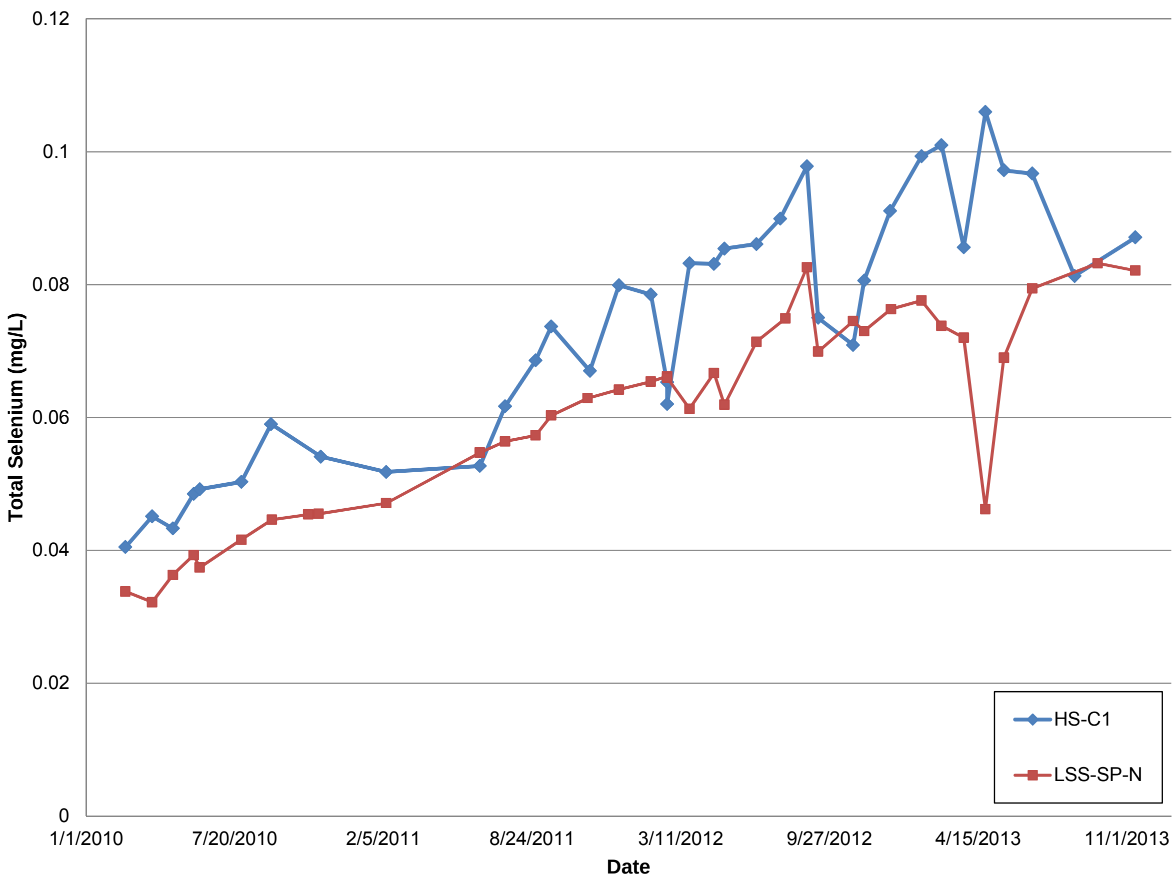

Figure 2-4. Time Series Comparison of Total Selenium Concentrations at Hoopes C1 Spring and South Fork Sage Creek SP-N Spring

water with the highest selenium concentrations so that the pilot treatment can have the maximum benefit in terms of reducing selenium in the Sage Creek watershed. Therefore, it is proposed to use a combination of the Liberty Pilot system drain at South Fork Sage Creek (LSS-SP-N) and water from the "C1" seep at Hoopes Spring (HS-C1) (see Figure 2-2 and Figure 2-3). Appendix A presents a discussion of estimated selenium removal from the watershed that would result from treating these two sources. The selenium concentrations in HS-C1 water are similar to those in LSS-SP-N (see Figure 2-4). Piping of water from South Fork

Sage Creek Springs to the Hoopes Spring vicinity will be required. The South Fork Sage Creek Springs will be developed in 2014 to capture a greater flow of the high-selenium concentration water (estimated to be in the range of 400-800 gpm; see Appendix A). The pumps and pipes needed for the developed springs would be constructed in the fall of 2014.

2.3 Technology Overview

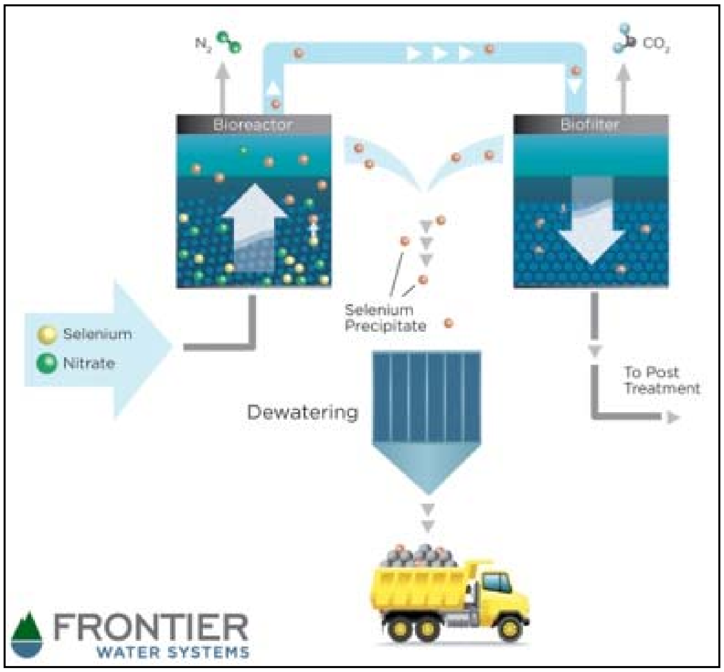

Figure 2-5. General Treatment Schematic

The Pilot Study will utilize a prefabricated, fluidized bed biological treatment system created by Frontier Water Systems (Frontier). Biological treatment systems use specialized microorganisms to reduce and precipitate metals, metalloids and non-metals from solution. The process of biological selenium reduction converts oxidized forms of selenium to the elemental state. The treatment chemistry is the same as for the ABMet® system (see Formation 2011a for a detailed discussion).

The treatment process consists of passing water at controlled flow rates through a confined bioreactor. Fixed bed bioreactors have been proven effective at removing dissolved metals from water (i.e., the ABMet® system tested at the Site in 2009), but have potential disadvantages of higher cost, relatively large footprints and difficult O&M for the polishing system. The Frontier system uses FBRs to address these issues. The fluidized bed gives a higher surface area exposure to the flow stream, thus requiring a smaller and more efficient reactor volume. The Frontier bioreactor contains microbial biofilms immobilized on a substrate (granular activated carbon of a specific diameter). Nutrients including carbon and phosphorus are fed into the reactor to encourage optimal reducing conditions for the microorganisms. As influent water flows upward through the bioreactor bed, the substrate fluidizes and oxidized selenium is converted to a particulate elemental form.

The second stage of the Frontier system consists of a proprietary filter media that has an affinity to elemental selenium. Selenium is ultimately removed from the system by backwashing the filter media. The general schematic for the Frontier process is shown as Figure 2-5.

Table 2-3. Pilot System Design Basis

Parameter	Influent Range	Pilot System Effluent
Flow	80 – 250 gpm	80 – 250 gpm
Total Selenium	80 - 100 µg/L	≤ 5 µg/L
Temperature[1]	9 – 12ºC	9 – 12ºC
BOD	< 2 mg/L	≤ 10 mg/L
DO	6 – 10 mg/L	≥6 mg/L
TSS	<10 mg/L	<10 mg/L
Turbidity	<2 NTU	<2 NTU
pH	6.5 – 9 su	6.5 – 9 su

Note:
1 – Temperatures at LSS-SP-N were measured 34 times between 2009 and 2013 and ranged from 9.4 – 10.2 ºC. Temperatures at HS-C1 were measured 50 times between 2008 and 2013 and ranged from 10.88 – 11.44 ºC.

2 – BOD effluent targets are related to maintaining DO concentrations in the receiving stream. These effluent limits will be assessed further during the pilot study.

Table 2-3 presents the influent and effluent design basis for the Pilot Study. As previously discussed, the influent water will consist of a combination of LSS-SP-N and HS-C1 water. Both sources are springs discharging from groundwater, with very little seasonal variation in temperature. It is anticipated that no additional temperature adjustment will be needed to maintain biological activity in the reactors through the winter. A detailed description of the pilot system is provided in Section 3.1.

2.4 Study Objectives

The Pilot Study is being conducted to evaluate the effectiveness, implementability, and cost of the Frontier fluidized bed bioreactor for removing selenium from South Fork Sage Creek Springs and Hoopes Spring water with selenium concentrations in the range of 0.05 to 0.1 mg/L. The Pilot Study will provide data for use in development and evaluation of water-treatment remedial alternatives for potential use at the Smoky Canyon Mine. The specific objectives of this Pilot Study are to:

- Determine the effectiveness of the fluidized bed bioreactor for removing total selenium to the lowest possible levels.
- Determine the technology’s applicability in meeting remedial action objectives developed for this Site.
- Determine operating parameters (e.g., back-flush frequency, hydraulic retention time, nutrient dosage, ferric chloride dosage, sludge generation rate and management procedures) to provide additional information regarding implementability and cost of the system.
- Evaluate process limitations with regards to levels of selenium and other COPCs in treated water, including any potential effects of other COPCs on the treatment efficiency of the system for selenium.

Although the primary purpose of this Pilot Study is to evaluate selenium removal, if there is also removal of other COPCs as a result of the treatment process, that information will be available for consideration during development and evaluation of remedial alternatives in the FS.

The types of data that will be collected to support these objectives and data uses are:

- Operation and maintenance parameters;
- Treated water/effluent characteristics;
- Process waste characteristics; and
- Operating cost.

3.0 PILOT STUDY DESIGN

This Pilot Study will evaluate the effectiveness of the system in removal of COPCs, particularly selenium, while treating water combined from specific locations in the South Fork Sage Creek Springs and Hoopes Spring complexes. As discussed in Section 2.1, selenium is the only COPC that has recently exceeded water quality standards in water discharging at the springs. However, given that the concentrations have been increasing and that this study is being performed under the RI, the full list of RI COPCs will be evaluated to be consistent with other pilot studies performed at the Site. This section describes the various elements of the Pilot Study.

3.1 Pilot Treatment System

This section provides a description of the Pilot Study system. A process flow diagram is provided in Figure 3-1.

Process equipment for the pilot system will be contained in a pre-engineered steel building (approximately 160 by 90 feet) including tankage, pumps, and chemicals. There will also be a 75,000 gallon tank located outside of the building for sludge storage. Water from South Fork Sage Creek Springs and Hoopes Spring will be piped and pumped to the treatment system building at a minimum combined flow rate of 250 gpm.

The pipeline alignment for influent and effluent water is shown in Figure 3-2. At South Fork Sage Creek Springs, spring water will be collected from the 8-inch buried pipeline that was installed for the ZVI pilot study. At Hoopes Spring, the HS-C1 spring water will be collected for use in the pilot system.

The collected spring water will be delivered to a wetwell located within the treatment building. Pumps within the wetwell will convey water to the FBRs following straining through an automatic filter. The automated influent filter will backwash periodically to a surge tank. The surge tank contents will be blended with the effluent water. The combined treated effluent and the surge tank effluent must meet the treatment system water quality requirements.

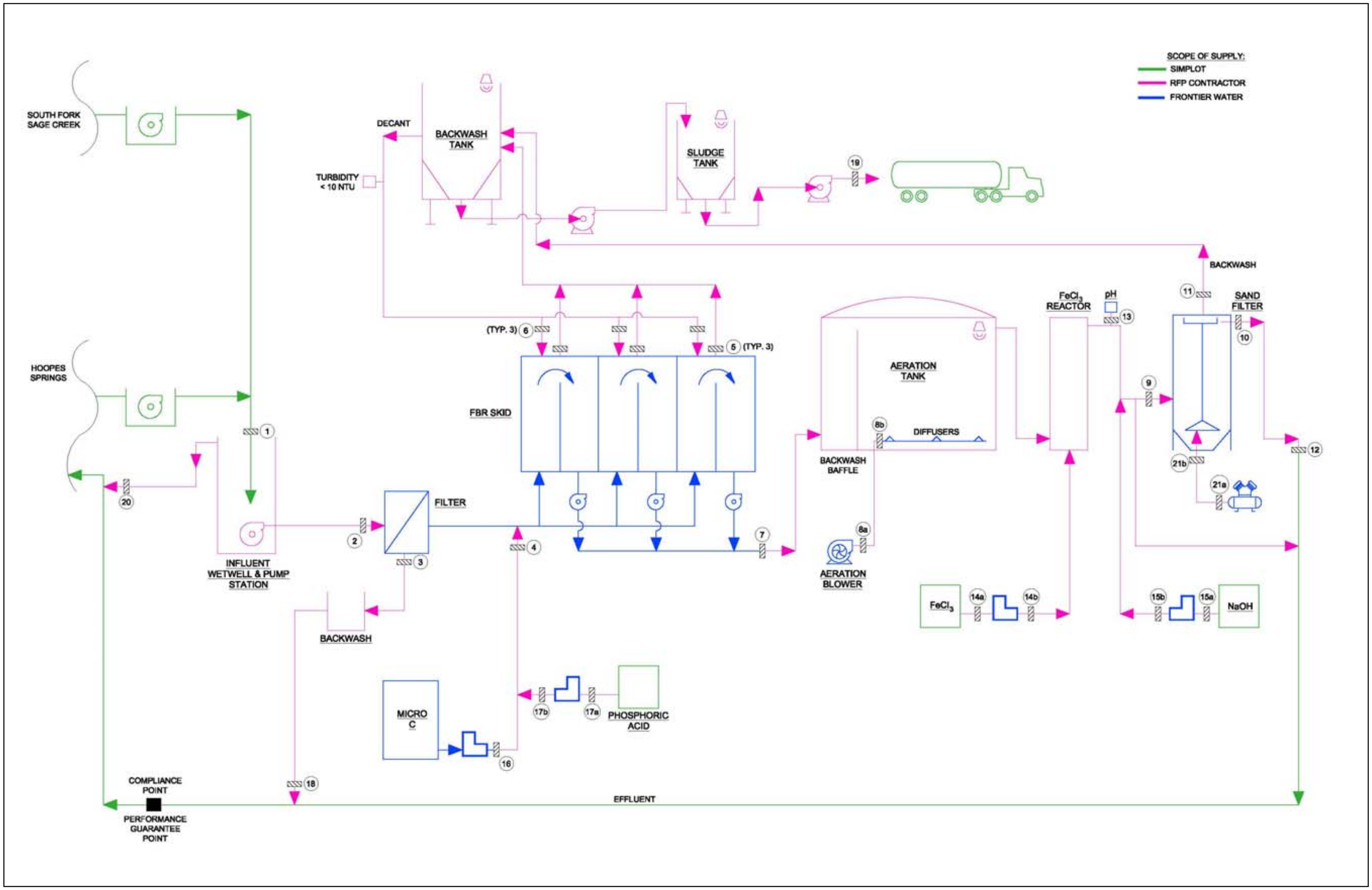

Figure 3-1. Process Flow Diagram

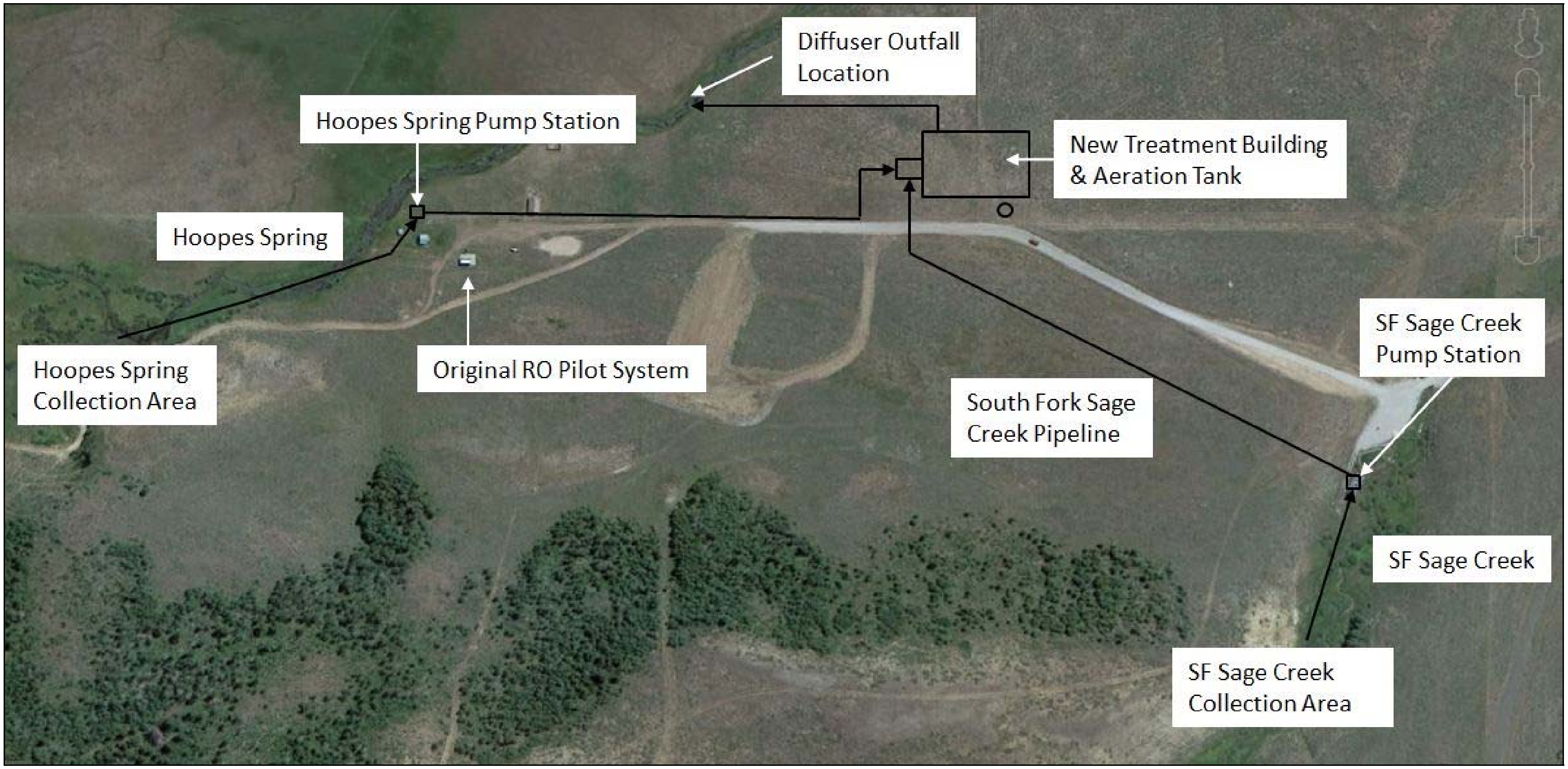

Figure 3-2. Pilot Study Location and Pipeline Configurations

Influent water will be mixed with a carbon source (Micro C 4400) and phosphoric acid prior to being delivered to the FBRs. The FBR system is comprised of 3 trains, each with a capacity of 83 gpm. Influent will be split between the available trains and controlled using a modulating flow control valve. In the first stage, a reducing environment is created within a fluidized stage that concurrently expels gas and maintains optimum biofilm conditions for selenium reduction and retention. The FBRs will generate biomass while precipitating the influent selenium. The FBRs will be periodically backwashed to transfer the biomass and precipitated solids to a backwash storage tank. The pumps that pull water from the FBRs and deliver it to the Aeration Tank can be operated in reverse. During the backwash cycle, treated water is pumped from the Aeration Tank to the FBR. The Aeration Tank inlet is baffled to prevent aerated water being pumped to the FBR.

The volume of backwash generated in each cycle is anticipated to range from 800 – 3,400 gallons. The backwash will be collected in a settling tank where the clarified water will be decanted back to the FBRs. Solids in the backwash settling tank will be periodically transferred to the sludge storage tank. The solids in the backwash settling tank are expected to gravity settle to a 2% total solids concentration without settling aids. The sludge storage tank has been sized based on the estimate of 120 gallons per day (gpd) of 2% solid sludge being transferred from the settling tank.

Treated water from the FBRs will be pumped to the Aeration Tank. An aeration blower and diffuser system will provide oxygen required to oxidize influent hydrogen sulfides. The aeration system provided within the Aeration Tank is sized to provide complete mixing within the tank which will maintain all solids in suspension. The Aeration Tank will be equipped with a mushroom style vent to allow blower air to escape from the tank. It is anticipated that sulfides will be fully oxidized to soluble sulfate ions within the Aeration Tank. As such, it is not expected that H_2S gas will be generated by the aeration process. However, as a precaution, H_2S monitors will be placed within the building to alarm if the H_2S concentration exceeds 10 ppm. A baffled area within the Aeration Tank will be the source of backwash water for the FBRs. The Aeration Tank effluent will flow by gravity to the ferric chloride reactor where ferric chloride addition will precipitate soluble phosphorus. Sodium hydroxide addition will be provided for pH adjustment if necessary. The pilot plant will be adjusting phosphorus addition rates in an attempt to reduce or eliminate the need for ferric chloride addition but still accomplish full selenium treatment. If phosphorus levels are below project standards without chemical precipitation, ferric chloride dosing will be suspended. The Aeration Tank also provides for COD reduction, in addition to sulfide oxidation, through biological aeration activity to meet project standards.

The biomass and precipitated elemental selenium generated within the FBRs and the Aeration Tank will be filtered out by the sand filter along with the precipitated iron (ferric) phosphate generated at the sand filter. Sand filter backwash will be delivered to the FBR backwash tank. The estimated backwash flow rate is 15 gpm. Effluent from the sand filter will be blended with the influent filter backwash prior to sampling for water quality compliance and treatment system performance evaluation. Effluent water will be discharged to Hoopes Spring (see Figure 3-2 for the location) via a submerged diffuser arrangement.

Secondary containment will be provided for all chemicals and the carbon source. Phosphoric acid will be in a 55 gallon drum or 250 gallon tote and the sodium hydroxide and ferric chloride will be in 55 gallon drums. The building is being built as a concrete basin to provide containment. Building containment volume will be approximately 50,000 gallons. All chemical totes and drums at the treatment building will be stored on movable plastic containment pallets which provide full secondary containment as added protection within the containment confines of the building.

3.2 Pilot Unit Preparation

The Pilot Study system location is shown in Figure 3-2. Simplot will provide necessary road maintenance during and after construction. Simplot will also refurbish the existing water collection systems at both springs, if necessary, and install pumps and piping to convey influent water to the Pilot Study location and effluent to the discharge point. The pipeline from the South Fork Sage Creek Springs will be buried to prevent freezing. Electricity is available at the Pilot Study location. Simplot’s contractor (to be selected) will construct the building and associated infrastructure for the Pilot Study. Actions proximal to stream channels will be performed in a manner to meet the substantive requirements of permits regarding stream alteration. A completed (but not submitted, because the work is being performed under CERCLA) Joint Application for Permit is included as Appendix B.

Frontier bioreactors can operate in a broad range of temperatures, but need to be situated under shelter and kept clear of snow during the winter. No heating of the influent water is required, although freeze protection such as insulation and heat tracing for exposed pipes (outside the building) is necessary for operations in cold weather.

3.2.1 Hoopes Springs Selenium Pilot Treatment System Creek Pumping Description

The selenium pilot treatment system will be fed by waters originating from both Hoopes Springs and South Fork Sage Creek Spring areas. The water will be collected and conveyed by gravity to the respective pump stations, where it will be pumped to the influent wetwell of the pilot treatment facility.

3.2.2 South Fork Sage Creek Pump Station Description

The South Fork Sage Creek Springs collection system (Figure 3-3) is in place and consists of an 8-inch diameter perforated plastic pipe trenched into the hillside above South Fork Sage Creek. The perforated piping is bedded in gravel and conveys water to a corrugated metal pipe (CMP) diversion box located to the east of the collection area. From the CMP diversion box, an 8-inch diameter HDPE gravity pipe will convey water to the wetwell of the South Fork Sage Creek pump station. The South Fork Sage Creek pump station will pump to the pilot treatment system via a 6-inch HDPE pressure pipe. The South Fork Sage Creek pump station will be a vertical turbine pump station with duplex pumps housed inside of a small building for freeze protection. The overflow will consist of a pipe penetration high in the wetwell which will extend approximately 10 feet from the edge of the pump station and discharge to a gravel and riprap lined channel which will extend to the edge of South Fork Sage Creek.

Figure 3-3. South Fork Sage Creek Collection and Conveyance

3.2.3 Hoopes Springs Pump Station Description

Water collection from Hoopes Spring (Figure 3-4) will originate from the HS-C1 location. An earthen dike will be installed below the confluence of the 8 springs located upgradient of HS-C1.

The dike will divert water into an 18-inch diameter HDPE pipe. The 18-inch diameter HDPE pipe will be connected to a concrete control box which will fill a 20-inch diameter HPDE gravity water line. The control box will overflow back to the creek if water demand is less than water supply. The wetwell of the lift station will include a pipe penetration located below the pump base level and located approximately 1 foot below ground level. The overflow pipe will extend from the pump station at minimum slope. The natural slope of the ground will cause the pipe to “daylight” and discharge to a constructed gravel and riprap-lined channel which will extend to the creek edge. The pipe will extend approximately 15 feet at the Hoopes Spring pump station. The 20-inch diameter HDPE gravity line will be buried adjacent to the creek and will deliver water to the Hoopes Springs pump station. Future water collection from the Hoopes Springs area will originate from the HS collection area and will consist of a similar dike and control box arrangement. The Hoopes Springs pump station will also include a duplex vertical turbine pump station housed within a small building for freeze protection.

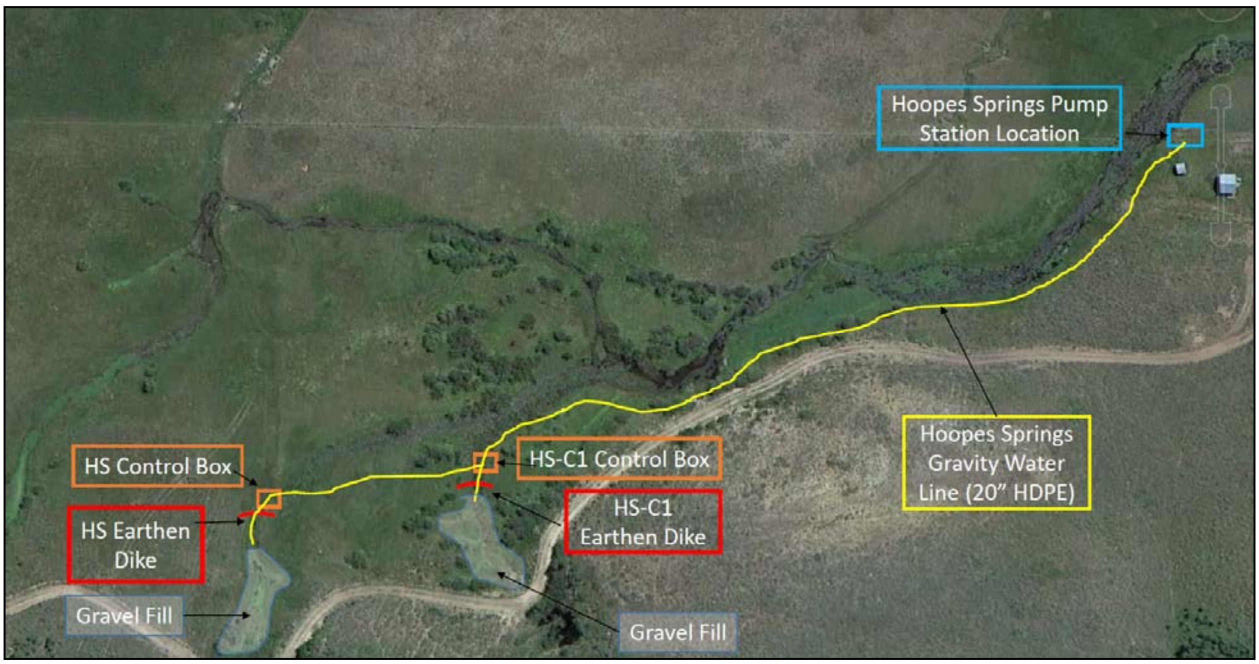

Figure 3-4. Hoopes Spring Collection and Conveyance

3.2.4 Collection and Pumping Rates

The pumping rates from South Fork Sage Creek Springs and Hoopes Springs are listed in Table 3-1. The initial collection and pumping rates will be adequate for the current treatment system water treatment capacity. Future collection and pumping rates are currently estimated, but should be adequate to meet the future treatment flow rates required. Figure 3-5 presents a comparison of measured flow rates to proposed pumping rates for each stage of the Pilot Study.

Table 3-1. Collection and Pumping Rates

South Fork Sage Creek Springs Pumping	
Current Pumping Rate	150 gpm
Current Gravity Flow Rate	150 gpm
Hoopes Springs Pumping	
Current Pumping Rate	150 gpm
Current Gravity Flow Rate	800 gpm from HS-C1

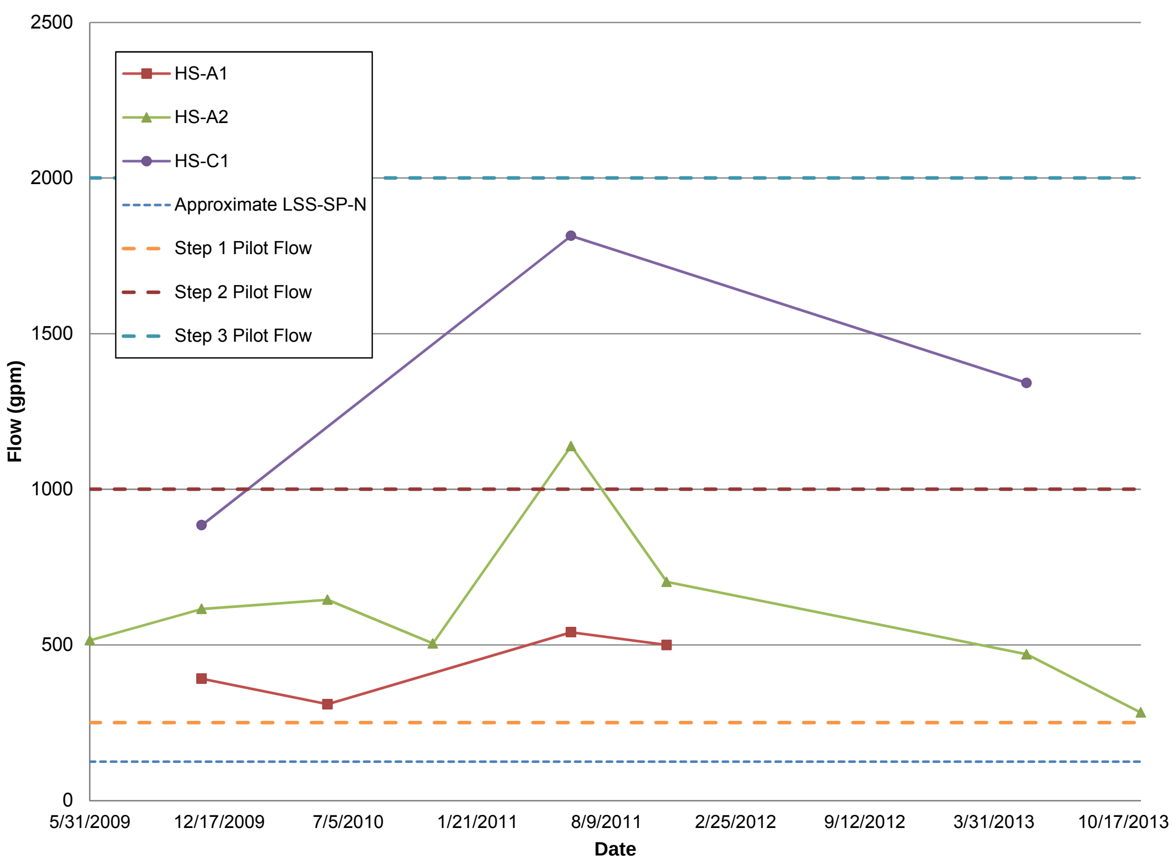

Figure 3-5. Historical Flow Rates Compared to Proposed Treatment Pumping Rates

3.3 Pilot Unit Operation

Water will be conveyed to the fluidized bed bioreactor module at a rate of up to 250 gpm, and an inlet pressure of 45-50 pounds per square inch gauge (psig). A 30-day commissioning is planned to commence with loop tests of all systems using spring water, prior to biological seeding and biological treatment. Following spring water commissioning, the biological reactors will be seeded and nutrient addition will commence.

During operation, a carbon source (Micro C 4400) and phosphoric acid will be added to the influent water prior to being delivered to the FBRs. The initial nutrient dosage has been determined based on the water chemistry data for the springs at 40 gpd. Initial dose rates for other chemicals are: 1 gpd phosphoric acid, 5 gpd ferric chloride, and 5 gpd sodium hydroxide. All chemicals will be stored on plastic chemical containment pallets located within the treatment building. The building is built as a concrete basin to provide containment of approximately 50,000 gallons. All chemical totes and drums at the treatment building will be stored on movable plastic containment pallets which provide full secondary containment as added protection within the containment confines of the building. A summary of expected chemical dosage and volume present is provided in Table 3-2.

Table 3-2 Chemical Dose Rates and Storage Volumes

Chemical	Description	Dosage Rate	Volume on Operations Floor	Volume in Chemical Storage Room	Days Between Vessel Replacement
Ferric Chloride 45%	Reddish, brown liquid with a slight pungent odor. pH < 1 Needed for- phosphorus removal	5 gpd	275 gallons	825 gallons	55 days
Phosphoric Acid 75%	Clear, colorless or light green, viscous liquid. pH 1 Needed for- biological growth	1 gpd	55 gallons	165 gallons	55 days
Sodium Hydroxide 25%	Clear, colorless, odorless liquid. pH 14 Needed for- pH adjustment	5 gpd	275 gallons	825 gallons	55 days
MicroC	Clear, yellow liquid. pH 4 Needed for- biological growth	40 gpd	6,000 gallons	NA	150 days
Polymer	Off white viscous liquid. pH 3-4 Needed for- solids settling	0.5 gpd	55 gallons	55 gallons	110 days

Nutrient dosage will be optimized during system operation based on oxidation-reduction potential (ORP), pH, and dissolved oxygen (DO) measurements. The dosage and nutrient feed rate will be adjusted as necessary to maintain ORP in the range of 0 mV to -250 mV for optimum selenium reduction. In the event of a nutrient-feed-system malfunction, the system alarm set points will shut down the system and warn the operator. Monitoring of the system will be performed via radio telemetry to the mine operations building. Visual alarms will be provided on the Supervisor Control and Data Acquisition (SCADA) screens both within the treatment plant and at the monitoring locations at the mine operations building. The system will be configured to terminate all pumping in the event of an alarm condition and manual restart of the treatment system will be required following investigation of the alarm issues.

Influent water will be monitored with inline probes that provide continuous read out for flow, pressure, temperature, pH, ORP, and DO. The FBR effluent will be monitored for pH, ORP and DO. The system effluent will be monitored for temperature, pH, ORP, and DO. Pump run status indicators will monitor system hydraulic function and accurate nutrient and chemical dosing.

The FBRs will generate biomass while consuming and filtering the influent selenium and will require backwashing to a storage tank. Settled sludge in the backwash storage tank will be periodically transferred to the sludge storage tank. The sludge storage tank is sized at 50,000 gallons. Sludge generation rates for the 250 gpm system are estimated in the range of 120 gpd at 2% solids (equivalent to 20 pounds per day of dry solids). The sludge storage tank has been sized to contain approximately 120 days of capacity in order to allow operation through the winter months without needing to empty the tank and dewater the sludge prior to disposal. The sludge storage tank is not expected to be increased in size for the full scale treatment system. More frequent pumping and hauling from the sludge storage tank will be required at the full scale treatment rates. Sludge characteristics and management procedures will be evaluated and optimized during the Pilot Study.

3.3.1 Pilot Unit Optimization

Optimization of the Pilot Unit to reach efficient removal conditions involves adjusting:

- Feed flow to determine best hydraulic retention time;
- Nutrient feed rates to optimize removal of dissolved selenium while minimizing sulfide production;
- Flush/chemical dosing rates to provide optimum polishing and sludge removal processes; and
- Sludge dewatering approaches to determine the most cost-effective method of sludge management and disposal.

Flow adjustment, system-optimization monitoring, and maintenance operations will continue throughout the duration of the Pilot Study.

3.3.2 Pilot Unit Monitoring

Monitoring of water streams conducted in the Pilot Study will include continuous monitoring of flow, pressure, temperature, pH, ORP, and DO using in-line measurement probes and then recorded via a wireless connection to a laptop computer. These data will provide the information needed to optimize the treatment system's operation and performance.

In addition, periodic sample collection and analysis will occur as described in Table 3-3. Samples may also be collected more frequently as necessary to characterize changes in performance due to system adjustments. The analyses and methods are shown in Table 3-4 and Table 3-5.

Table 3-3. Pilot Study Monitoring, Sampling, and Analysis Schedule

System Status	Sampling Frequency	Sampling Locations	Analyses to be Performed	Lab Turnaround Time
Initial Steady State Flow After Start Up (week 0)	One-time	Influent, effluent FBR effluent	Full analytical suite[a]	Routine
Operational (weeks 2-6)	Every two weeks	Influent, effluent	Full analytical suite[a]	Routine
Operational (weeks 2-6)	Every two weeks	Influent, effluent	Focused analyte suite[b]	48 hours[c]
Operational (after week 6)	Every two weeks	Influent, effluent	Focused analyte suite[b]	48 hours[c]
Operational (after week 6)	Quarterly	Influent, effluent	Full analytical suite[a]	Routine
Operational – Immediately Prior to Shut Down	One-time	Influent, effluent FBR effluent	Full analytical suite[a]	Routine

Notes:
a – Refer to Table 3-4 for list of analyses and methods.
b – Refer to Table 3-5 for list of analyses and methods.
c – Data will be available in 4-5 days after sample collection depending on shipping logistics.

Table 3-4. Laboratory Analyses, Methods and Reporting Limits – Full Analytical Suite

Laboratory Analyses	Method	Reporting Limit (RL)[1] (mg/L)
Alkalinity, as CaCO3	SM 2320B	1
Aluminum, total and dissolved	EPA 6010C	0.1
Ammonia as N	SM 4500 NH3 G	0.03
Antimony, total and dissolved	EPA 6020A	0.003
Arsenic, total and dissolved	EPA 6020A	0.003
Barium, total and dissolved	EPA 6020A	0.001
Beryllium, total and dissolved	EPA 6020A	0.0002
Biological Oxygen Demand	EPA 405.1	2
Boron, total and dissolved	EPA 6020A	0.05
Cadmium, total and dissolved	EPA 6020A	0.0002
Calcium, dissolved	EPA 6020A	0.05
Chemical Oxygen Demand	EPA 410.4	5
Chloride	EPA 300.0	0.2
Chromium, total and dissolved	EPA 6020A	0.0015
Cobalt, total and dissolved	EPA 6020A	0.001
Copper, total and dissolved	EPA 6020A	0.001
Fluoride	EPA 300.0	0.1
Hardness	SM 2340B (by calculation)	0.1
Iron, total and dissolved	EPA 6010C	0.06
Lead, total and dissolved	EPA 6020A	0.003
Magnesium, dissolved	EPA 6010C	0.10
Manganese, total and dissolved	EPA 6020A	0.001
Mercury, total and dissolved	EPA 7470A	0.0002
Molybdenum, total and dissolved	EPA 6020A	0.001
Nickel, total and dissolved	EPA 6020A	0.001
Nitrate+Nitrite as N	EPA 353.2	0.05
Nitrate, as N	EPA 300.0	0.05
Total Phosphorus	SM 4500 PE	0.01
Potassium, dissolved	EPA 6010C	0.5
Selenium, total and dissolved	EPA 6020A	0.003
Selenate and selenite, dissolved	IC-ICP-DRC-MS	0.003 and 0.003
Organic selenium species (dimethyl selenide and dimethyl diselenide)	HPLC-ICP-DRC-MS	0.001 and 0.0015
Silver, total and dissolved	EPA 6020A	0.0001
Sodium, dissolved	EPA 6010C	0.5
Sulfate	EPA 300.0	1.0
Thallium, total and dissolved	EPA 6020A	0.001
TDS	SM 2540C	10
TOC	SM 5310B	1

Laboratory Analyses	Method	Reporting Limit (RL)[1] (mg/L)
TSS	SM 2540D	5
Uranium, total and dissolved	EPA 6020A	0.001
Vanadium, total and dissolved	EPA 6020A	0.0015
Zinc, total and dissolved	EPA 6020A	0.005

[1] Each laboratory's MDLs and RLs may change over time.

Table 3-5. Laboratory Analyses, Methods and Reporting Limits – Focused Analytical Suite (Routine Samples)

Laboratory Analyses	Method	Reporting Limits (RL)[1] (mg/L)
Routine Monitoring Parameters		
Selenium, dissolved	EPA 6020A	0.003
Selenium, total	EPA 6020A	0.003
Nitrate, as N	EPA 300.0	0.05

In order to accurately reflect actual operational parameters, all sample collection activities will be conducted when the system is running under stable operating conditions. In addition, samples may be collected during unstable conditions for optimization/troubleshooting. The full analytical suite (**Table 3-4**) includes all of the RI COPCs and other parameters needed to evaluate the operation of the system. The focused analytical suite provides additional data for tracking selenium and nitrate concentrations over time. Sample preservation and holding times will be addressed as specified in Table 3-6. Section 6.0 describes these sampling and analysis activities in greater detail, and identifies individual laboratories performing analyses and specific turnaround times. Together, Section 6.0 of this plan and the Quality Assurance Project Plan (QAPP), which is included in the Smoky Canyon Mine RI/FS Sampling and Analysis Plan (Formation 2010b), shall serve as the main reference for field and laboratory personnel conducting this work.

Table 3-6. Sample Preservation and Holding Times

Analyte	Preservation and Storage [1]	Holding Time (days unless otherwise specified)
Total metals (excluding mercury), Hardness	HNO_3 to pH < 2, Cool at 4ºC ± 2ºC	180
Total mercury	HNO_3 to pH < 2, Cool at 4ºC ± 2ºC	28
Dissolved metals (excluding mercury), Hardness	Field filter; HNO_3 to pH < 2, Cool at 4ºC ± 2ºC	180
Dissolved mercury	Field filter; HNO_3 to pH < 2, Cool at 4ºC ± 2ºC	28
Ammonia, Total Phosphorus, Nitrate+Nitrite, COD	H_2SO_4 to pH < 2, Cool at 4ºC ± 2ºC	28
TOC	H_2SO_4 to pH < 2 (amber glass vial), Cool at 4ºC ± 2ºC	28
BOD	Cool at 4ºC ± 2ºC	2
Chloride, Fluoride, Sulfate	Cool at 4°C ± 2°C	28
Alkalinity	Cool at 4ºC ± 2ºC	14
TDS, TSS	Cool at 4ºC ± 2ºC	7
Nitrate, as N	Cool at 4ºC ± 2ºC	2
Dissolved selenite, selenate	Field filter; Cool at 4ºC ± 2ºC	2 or as soon as practical

[1] Sufficient ice shall be included in the shipping containers to ensure that samples arrive at the laboratory within the appropriate temperature range.

3.4 Investigation-Derived Waste Management and Demobilization

The investigation-derived waste (IDW) generated by the Pilot Study will be:

1) The substrate from the fluidized bed stage;
2) The used filter media; and
3) The dewatered backwash from the filtration stage.

These materials will be sampled and analyzed using toxicity characteristic leaching procedure (TCLP) consistent with the procedures described in Section 6.2.3. Simplot will be responsible for disposal of IDW during and at the end of the study.

Additional IDW may include disposable sampling equipment, personal protective equipment, decontamination water, and spent calibration solution. All disposable sampling materials and personal protective equipment, such as disposable spoons, gloves, and other items used in sample processing, will be disposed as regular municipal solid waste at a Subtitle D Landfill.

As discussed above, it is expected that the technology will prove effective and that the system will be expanded in 2015-2016. Therefore, system demobilization is not expected. However, if the system is demobilized, Frontier representatives and Site personnel will prepare the unit for shipment back to Frontier's facility in Salt Lake City, Utah. This will entail:

- Backflushing of the bioreactors;
- Collection of all remaining sludge in a tank;
- Testing of sludge prior to disposal;
- Draining the bioreactors;
- Disconnecting utilities; and
- Disconnecting the raw feed, treated effluent, and flush lines.

3.5 Proposed Schedule and Schedule Considerations

The working schedule for construction/startup of the system is:

- October 1 – System is Substantially Complete and Ready for System Commissioning; and
- November 1 – System Operational.

The system performance will be assessed over the winter. If the technology is proven effective and no significant operational issues are identified, Simplot will submit a work plan addendum to increase the Pilot Study treatment capacity to at least 1,000 gpm in the spring of 2015-2016.

4.0 DATA QUALITY OBJECTIVES

The following sub-sections describe the types and quality of data needed to support the evaluation of the treatment system's implementability and effectiveness, consistent with EPA's *Guidance for Conducting Treatability Studies under CERCLA* (EPA, 1992).

4.1 Problem and Decision Statements

Problem Statement - Levels of selenium in the surface waters at the Site exceed the surface water quality standard of 0.005 mg/L, and selenium concentrations in certain springs at the South Fork Sage Creek Springs and Hoopes Spring complexes can exceed 0.08 mg/L. Biological treatment has been shown to effectively remove selenium from Site water, but fluidized bed bioreactors and associated secondary treatment steps have not been tested. A field-scale study is needed to evaluate whether the fluidized bed bioreactor technology is feasible to implement at the Site for treatment of water discharging at the springs and to determine whether it can effectively remove selenium from Site waters while producing manageable effluent and process-waste streams.

Decision Statement - Can the fluidized bed bioreactor effectively remove selenium, and other COPCs, from Site waters while producing manageable effluent and process-waste streams?

4.2 Inputs to the Decision and Decision Rules

In order to evaluate whether this treatment system can effectively remove COPCs from the Site waters, water from relatively-high selenium concentrations springs at South Fork Sage Creek and from Hoopes Spring will be tested. The following decision inputs are needed and decision rules apply.

Decision Input (1) - Are the selenium concentrations in the treatment system effluent less than the COPC concentrations in the untreated influent?

> **Decision Rule (1)** - If an overall decrease in selenium concentrations is measured in the treated effluent relative to the untreated influent, the system is effective in removing selenium from water discharging at South Fork Sage Creek Springs and Hoopes Spring and likely effective in treating other Site waters.

Decision Input (2) – Are the selenium concentrations in the treatment system effluent less than their Idaho surface water quality standard of 0.005 mg/L?

Decision Rule (2) – If the selenium concentrations in treated effluent are greater than the standards, then the treatment system is not effective in achieving Idaho's regulatory standards for surface water when treating water from the springs.

Decision Input (3) – Are the physical and chemical characteristics of the treated effluent water suitable to allow effluent discharge to streams that support aquatic life?

Decision Rule (3) – Effluent water samples will be analyzed for the water-quality parameters listed in **Table 3-4**, including inorganic and organic selenium species. Total selenium will be compared to the water quality standard shown in Table 4-1, while the other parameters will be compared to their respective influent concentrations. If effluent concentrations are below influent concentrations (and the water quality standard for total selenium), then effluent is suitable to be discharged to streams that support aquatic life. If concentrations are above the standard and influent concentrations, then mixing zone/dilution factors should be considered when determining whether the effluent would have the potential to cause exceedances of water quality standards in the receiving stream.

Decision Input (4) - What are the characteristics of process-waste streams?

Decision Rule (4) – Samples of sludge, bioreactor substrate and used filter media will be collected and analyzed for hazardous waste characterization. Samples will be analyzed for metals, and results compared to maximum concentration of contaminants for toxicity characteristic criteria. If results exceed these regulatory limits, the waste would be disposed as hazardous.

4.3 Null Hypotheses and Limits on Decision Errors

The first null hypothesis for this study is that fluidized bed bioreactor technology cannot effectively remove COPCs from affected Site waters. The alternative is that this technology does reduce the COPC concentrations.

There are two types of decision errors: a false rejection error (Type 1) and a false acceptance error (Type 2). A Type 1 error is determining that elevated COPC concentrations remain in the treated effluent relative to the influent, indicating ineffective treatment; when, in fact, COPC concentrations have decreased. A Type 2 error is determining that COPC concentrations in the effluent are reduced relative to influent concentrations, indicating that the treatment is effective; when, in fact, COPC concentrations in the effluent are not reduced relative to the influent. A Type 1 error may result in a decision not to adopt a treatment system. A Type 2 error may result in adopting and inadequate treatment and continued discharge of elevated COPC concentrations.

The second null hypothesis for this study is that the fluidized bed bioreactor technology cannot achieve the surface water quality standards for COPCs in the springs water. The alternate hypothesis is that the treatment system does achieve the surface water quality standards. The Type 1 error in this case would lead to a conclusion that the treatment system does not achieve the standards when it actually does. The Type 2 error would lead to a conclusion that the treatment system does achieve the standards when it actually does not.

The third null hypothesis for this study is that the fluidized bed bioreactor technology produces changes in influent water physical and chemical properties (i.e. temperature, suspended solids/turbidity, dissolved oxygen, and major-ion content) that are not compatible with stream water that support's aquatic life. Type 1 error in this case would lead to a conclusion that the treatment system effluent is not compatible with stream water when it actually is. The Type 2 error would lead to a conclusion that the treatment system is compatible with stream water when it actually is not.

The fourth null hypothesis for this study that the fluidized bed bioreactor technology produces process waste that would be classified as hazardous (with TCLP characteristics exceeding regulatory limits). The alternative is that the treatment system does not produce process-waste that would be classified as hazardous (with TCLP characteristics below regulatory limits). A Type 1 error is determining that the process waste would be classified as hazardous, indicating that the waste does have to be disposed as hazardous waste; when, in fact, it does not. The Type 2 would determine that the process waste would not be classified as hazardous, indicating that the waste does not have to be disposed as hazardous waste when, in fact, it does.

The number of samples collected to test the null hypotheses presented above needs to be sufficient to allow for decision making at acceptable confidence levels.

- The first hypothesis will be tested through comparison of the influent and effluent COPC concentrations. A statistical test will be performed to compare the two sets of COPC concentrations, and that test will have 95 percent confidence level for detecting differences between the two data sets. In this case the Type 1 error rate will be 5 percent.
- The second hypothesis will be tested through comparison of the mean effluent COPC concentrations to the surface water quality standards. A 95 percent confidence limit on the mean is a commonly applied basis for comparison to a regulatory standard.
- The third hypothesis will be tested through comparison of effluent water physical and chemical characteristics to those characteristics in the influent water and water quality standards. These comparisons will indicate whether there are physical and chemical changes caused by treatment using the Pilot Unit that could have effects on aquatic life in local stream waters receiving treated effluent water.
- The fourth hypothesis will be tested through comparison of process waste TCLP test results to the regulatory criteria. Each test result will be compared directly to the regulatory criteria.

To control decision errors, only quantitative data with acceptable accuracy and precision documentation will be used for comparison to standards. Samples will be analyzed by SVL Analytical, Applied Speciation and Consulting, and IAS Analytical using EPA-approved methods with detection limits below the surface water quality standard for selenium and other COPCs. Water samples collected for analyses of selenium species will be submitted to Applied Speciation and Consulting (pending USFS approval), which provides the specialized analysis methods required for speciation analyses. Measurement errors for all sample analyses will be minimized by implementing standard procedures for the sample collection, handling, preparation, and analysis methods, as described below in Section 6.0.

4.4 Optimizing the Sampling Design

The sampling design, strategy, and quality assurance (QA) requirements are presented in the Sampling and Analysis Plan (SAP), which is Section 6.0 of this document. Additional samples may be collected during the Pilot Study, if and as necessary, to increase the confidence of decision making in accordance with the data quality objectives (DQOs) set forth in this plan.

Table 4-1. Screening Level Benchmarks for Surface Water (Formation 2014a)

Monitoring Parameter	Units	Achievable Laboratory Limits [1]		National Recommended Water Quality Criteria -Aquatic Life[2,a]		Aquatic Life Secondary Values		Selected Bench-mark[7]
		RL	MDL	Acute	Chronic	Chronic	Source	
Trace-level Parameters								
Aluminum	mg/L	0.1	0.05	NA	NA	**0.087**	[3]USEPA 1986	**0.087**
Antimony	mg/L	0.003	0.00022	NA	NA	**0.24**	[3]USEPA 1986	**0.24**
Arsenic	mg/L	0.003	0.0005	0.34	**0.15**	NA		**0.15**
Barium	mg/L	0.001	0.00003	NA	NA	**0.44[b]**	[4]MDEQ 2009 - FCV	**0.44[b]**
Beryllium	mg/L	0.0002	0.000029	NA	NA	**0.01[b]**	[4]MDEQ 2009 - FCV	**0.01[b]**
Boron	mg/L	0.05	0.02	NA	NA	**5.00**	[4]MDEQ 2009 - FCV	**5.00**
Cadmium	mg/L	0.0002	0.000024	0.0020[b]	**0.00025[b]**	NA		**0.00025[b]**
Chromium (total)	mg/L	0.0015	0.00023	0.57[b,c]	**0.074[b,c]**	NA		**0.074[b,c]**
Cobalt	mg/L	0.001	0.000013	NA	NA	**0.10**	[4]MDEQ 2009 - FCV	**0.10**
Copper	mg/L	0.001	0.000073	0.013[b]	**0.0090[b]**	NA		**0.0090[b]**
Iron	mg/L	0.06	0.02	NA	NA	**1.00**	[3]USEPA 1986	**1.00**
Lead	mg/L	0.003	0.000053	0.065[b]	**0.0025[b]**	NA		**0.0025[b]**
Manganese	mg/L	0.001	0.000021	NA	NA	**1.65[a,b]**	[5]CDPHE 2009	**1.65[a,b]**
Mercury	mg/L	0.0002	0.00006	0.0014	**0.00077**	NA		**0.00077**
Molybdenum	mg/L	0.001	0.0001	NA	NA	**3.2[b]**	[4]MDEQ 2009 - FCV	**3.2[b]**
Nickel	mg/L	0.001	0.00011	0.47[b]	**0.052[b]**	NA		**0.052[d]**
Selenium	mg/L	0.003	0.0002	0.005[d,e]	**0.0050[e]**	NA		**0.0050[e]**
Silver	mg/L	0.0001	0.000019	**0.0032[b]**	NA	NA		**0.0032[d]**
Thallium	mg/L	0.001	0.000023	NA	NA	**0.0072**	[4]MDEQ 2009 - FCV	**0.0072**
Uranium	mg/L	0.001	0.0000081	NA	NA	**1.5[b,a]**	[5]CDPHE 2009	**1.5[b,a]**
Vanadium	mg/L	0.0015	0.0003	NA	NA	**0.012**	[4]MDEQ 2009 - FCV	**0.012**
Zinc	mg/L	0.005	0.00048	0.12[b]	**0.12[b]**	NA		**0.12[b]**
Major Ions								
Calcium	mg/L	0.05	0.02	NA	NA	NA	g	NA
Magnesium	mg/L	0.10	0.02	NA	NA	g	g	g
Potassium	mg/L	0.5	0.1	NA	NA	g	g	g
Sodium	mg/L	0.5	0.05	NA	NA	g	g	g
Alkalinity, as CaCO3	mg/L	1	1	NA	NA	g	g	g

Monitoring Parameter	Units	Achievable Laboratory Limits [1]		National Recommended Water Quality Criteria -Aquatic Life[2,a]		Aquatic Life Secondary Values		Selected Bench-mark[7]
		RL	MDL	Acute	Chronic	Chronic	Source	
Chloride	mg/L	0.2	0.1	NA	NA	g	g	g
Sulfate	mg/L	1.0	0.5	NA	NA	g	g	g
Other Water Quality Parameters								
Nitrate + Nitrite as N	mg/L	0.05	0.025	NA	NA	NA		NA
TDS	mg/L	10	5	NA	NA	**1134[f]**	[6]Chapman et al. 2000	**1134[f]**
TSS	mg/L	5	2.5	NA	NA	NA		NA

Notes:

This table is from Table 6-1 of the RI/FS Work Plan.

CCC - Criteria continuous concentration (chronic criteria)
CMC - Criteria maximum concentration (acute criteria)
CWA - Clean Water Act
IDAPA Idaho Administrative Protection Agency'
IDEQ - Idaho Department of Environmental Quality
MDL - Method detection limit
mg/L - milligrams per liter
NA - not applicable to this method
RL - Reporting limit
TDS - total dissolved solids
TSS - total suspended solids

[1] RLs and MDLs are subject to change based on the laboratory capabilities at the time of sample submittal.
[2] Freshwater standards from IDAPA 58.01.02.210 and from U.S. Environmental Protection Agency (USEPA). 2009. National Recommended Water Quality Criteria (NRWQC) for Priority Pollutants. EPA Office of Water, Office of Science and Technology (4304T). Available at http://www.epa.gov/waterscience/criteria/wqcriteria.html. Updated December 2, 2009; Acute Criteria (CMC) and Chronic Criteria (CCC).
[3] U.S. Environmental Protection Agency (EPA). 1986. Quality Criteria for Water 1986 ("The Gold Book"). EPA 440/5-86-001. May 1, 1986.
[4] Michigan Department of Environmental Quality (MDEQ). 2009. Freshwater Chronic Values (FCV) from Rule 57 Water Quality Values based on Rule 323.1057 (Toxic Substances) of the Part 4. Water Quality Standards gives procedures for calculating water quality values to protect humans, wildlife and aquatic life. http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-11383--,00.html. Updated December 11, 2009.
[5] Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Commission (WQCC). 2007. Reg. Number 32. Classifications and Numeric Standards for the Arkansas River System, updated February 2009. Available at http://www.cdphe.state.co.us/regulations/wqccregs/100232arkansasriverbasinnew.pdf.
[6] Chapman, P.M., H. Bailey, and E. Canaria. 2000. Toxicity of Total Dissolved Solids Associated with Two Mine Effluents to Chironomid Larvae and Early Lifestages of Rainbow Trout. Environmental Toxicology and Chemistry: Vol. 19, No. 1, pp. 210–214.

[7] Benchmarks selected based on chronic national water quality criteria first, then on secondary chronic criteria for aquatic life. In the case of silver, no chronic values were available, and the benchmark is based on the acute criteria.

[a] Metals are stated as dissolved unless otherwise specified.
[b] The freshwater criterion for this metal is expressed as a function of hardness (mg/L) in the water column. The value given here corresponds to a hardness of 100 mg/L. Criteria values for other hardness may be calculated from the following:

CMC (dissolved) = exp{mA [ln(hardness)]+ bA} (CF)
CCC (dissolved) = exp{mC [ln(hardness)]+ bC} (CF)

[c] Criterion is expressed as total recoverable (unfiltered) concentration.
[d] The CMC for selenium = 1/[(f1/CMC1)+(f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 0.1859 mg/L and 0.01282 mg/L, respectively.

[e] This recommended water quality criterion for selenium is expressed in terms of total recoverable metal in the water column. It is s scientifically acceptable to use the conversion factor (0.996- CMC or 0.922-CCC) that was used in the GLI (60FR15393-15399, March 23, 1995; 40CFR132 Appendix A) to convert this to a value that is expressed in terms of dissolved metal.
[f] No observed effects level of chironomids
[g] No criteria available, but considered as a component in total dissolved solids (TDS)
Gray shading denotes the screening level selected for comparison.

5.0 ROLES AND RESPONSIBILITIES

Pharmer Engineering has been selected as the Owner's representative and will coordinate design, bidding, and construction.

Frontier is the vendor that will be operating the treatment system. Frontier is responsible for:

- Pilot system design and procurement;
- Selecting the microbial combination and nutrient blends;
- Pilot Unit start-up, training, performance monitoring, maintenance, shut-down;
- Off-site transport of the Pilot Unit; and
- Performance data interpretation.

The Simplot contact for overall management of this Pilot Study will be Monty Johnson. The Simplot contact for technical design, operation, and maintenance of the Pilot Study will be Henry Hamanishi. The Smoky Canyon Mine Manager will assign appropriate personnel responsible for operation of this pilot unit and any ancillary equipment. Simplot is responsible for:

- Implementation of the project;
- Communication with the agencies;
- Connecting the Pilot Unit to power and internet services;
- Providing staff for daily on-Site operation and routine sampling of the Pilot Unit;
- Contracting a laboratory for sample analysis; and
- Disposal of the IDW, and demobilization.

Formation Environmental is the CERCLA consultant/contractor to Simplot and is responsible for integrating the Pilot Study results into an evaluation of the technology's effectiveness and implementability.

The USFS and supporting agencies will perform oversight of the Pilot Study implementation, and make determinations, approvals, or disapprovals for any action under State and Federal law.

Simplot personnel performing the day-to-day operation of the treatment system will be trained by Frontier representatives. All personnel operating the treatment system and conducting sampling activities must have appropriate health and safety training before starting work on the Site. Contractors will provide a Health and Safety Plan for Simplot review prior to mobilizing to the Site. Simplot will provide MSHA training, as needed.

6.0 SAMPLING AND ANALYSIS PLAN

This SAP details the procedures for sampling and data collection during the Pilot Study. The SAP is organized as follows: Section 6.1 describes routine field measurements for system optimization; Section 6.2 explains the project sampling design and sampling methods; Section 6.3 discusses documentation and sample handling; Section 6.4 outlines the Data Quality Indicators (DQIs); Section 6.5 outlines any project-specific Quality Assurance (QA) and Quality Control (QC) requirements; Section 6.6 presents the data review and reduction protocols; and Section 6.7 identifies data management activities. Additional QA/QC procedures and specifications are provided by the QAPP developed for use in the Smoky Canyon Mine RI/FS (Formation 2010b), which serves as a companion document with this plan to guide the sampling and analysis activities associated with the water treatment system. Both this plan and the QAPP should be referred to by the field and laboratory personnel performing the work described herein.

6.1 Routine Operations Monitoring for System Optimization

Monitoring of water streams conducted in the Pilot Study will entail documenting:

- Influent flow, pressure, temperature, pH, ORP, and COPC concentrations;
- Bioreactor effluent pH and ORP;
- Dose rates of nutrients and other chemicals; and
- Effluent temperature, pH, DO, and COPC concentrations.

As previously mentioned, the Pilot System will be equipped with dedicated in-line instruments to continuously monitor flow, ORP, pH, DO, and temperature.

6.1.1 Field Equipment Testing and Calibration Procedures

Equipment needing calibration, such as the above-mentioned water-quality instruments, will be calibrated during commissioning of the Pilot Unit and checked once a week using calibration standards to ensure that the accuracy and reproducibility of the results are consistent with the manufacturer’s specifications and the project's data needs. In the event that a field instrument cannot be calibrated to meet the manufacturer’s specifications, it will be serviced or replaced.

6.1.2 Field Equipment Decontamination

The sampling program minimizes potential cross-contamination of samples by utilizing clean disposable equipment to collect samples directly from the water sampling ports. Any necessary equipment decontamination will be performed as outlined in Standard Operating Procedure (SOP) No. 7 (Appendix C).

6.2 Sampling Design and Methods

In order to address the data quality objectives described above in Section 4.0, water samples will be collected before, during, and after operation of the pilot treatment system. Waste samples will be collected at the completion of the Pilot Study. These sampling activities are described separately below.

6.2.1 Performance Monitoring Sampling Design and Methods

System performance will be monitored through routine collection and analysis of samples from three points in the treatment process:

1. Influent;
2. FBR discharge; and
3. Effluent.

The samples will be analyzed for monitoring parameters listed on **Table 3-4**, as described in greater detail in the next section, to evaluate the system's overall performance in achieving specific water treatment objectives described above in Section 4.0.

6.2.2 Routine Performance Evaluation Sampling

Routine performance monitoring samples will be collected once every two weeks, or as frequently as necessary to characterize changes in performance due to system adjustments. Sample collection will occur as needed to accurately reflect operational parameters. Routine performance monitoring samples will be analyzed for the focused analytical suite that was defined in Table 3-5:

- Total selenium,
- Dissolved selenium, and
- Nitrate.

The focused analytical suite may be revised to include additional parameters if warranted following a review of the initial monitoring data collected for the full analytical suite (**Table 3-4**) through the first 6 weeks of system operations.

Due to the 48 hour hold time for nitrate analyses, the samples will be transported via overnight courier to IAS EnviroChem in Pocatello, Idaho within 24 hours of collection. This will allow the lab 24 hours for analyses which will meet the 48-hour hold time. In addition, the lab will report preliminary total selenium and nitrate concentrations promptly to expedite any corrective actions needed during operation.

In addition, samples will be collected at the influent and effluent once the system has reached steady-state flow after startup biweekly during the first 6 weeks of operation and quarterly thereafter and analyzed for the full analytical suite (Table 3-4). These samples will be analyzed by SVL Analytical (and Applied Speciation and Consulting) with a standard turnaround time.

Contracted laboratories will provide pre-cleaned sample containers and appropriate preservation reagents. Preservation and storage requirements associated with the individual analyses to be performed and the referenced analytical methods are summarized in Table 3-6.

Field parameters, including DO, pH, ORP, temperature, and flow will be measured and recorded using instruments integrated into the system. Additional details on collecting field measurements, including calibration and any decontamination procedures, are provided in Section 6.1 and the QAPP (Formation 2010b).

6.2.3 Waste Characterization Sampling and Analysis

The IDW generated by the treatment process will include bioreactor substrate, used filter media, and sludge. Additional IDW may include disposable sampling equipment, personal protective equipment, decontamination water, and spent calibration solution. Simplot will dispose the IDW at the completion of the study.

Sludge will be collected for analysis prior to disposal. Bioreactor substrate and media filter will be analyzed if it becomes spent. Each sample will be collected as a composite comprised of five discrete grab samples each consisting of 100-200 grams of solid material (wet weight). Each grab sample will be composited together in a single container and homogenized using procedures consistent with sediment sampling procedures described in SOP No. 14 (Appendix C). The solids/sludge sample will be stored at approximately 4°C and shipped via overnight courier to SVL Analytical for analysis using TCLP for the 8 Resource Conservation and Recovery Act (RCRA) metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) to determine the proper course of disposal according to local regulations.

6.3 Sample Documentation and Handling

Sample collection activities will be documented in field notebooks and on field forms according to methods outlined in SOP No. 1 (Appendix C).

6.3.1 Field Notes

Documentation of observations and data acquired during the Pilot Study will be recorded with waterproof ink in a permanently bound weatherproof field log book with consecutively numbered pages, or on field data sheets. Wherever a sample is collected or a measurement is made onsite, a detailed description of the sample location and any additional observations will be recorded.

Field notebook and data sheet entries will, at a minimum, include the information listed below:

- Project name and number;
- Location of sample;
- Data and time of sample collection;
- Sample identification numbers;
- Description of sample (sample matrix or species);
- Number of samples collected;
- Field measurements;
- Field observations and weather conditions;
- Personnel present; and
- Sampler's signature.

Changes or deletions in the field book or on the data sheets will be recorded with a single strike mark through the changed entry, with the sampler’s initials and the date recording the new entry. All entries must remain legible. Sufficient information should be recorded to allow the Pilot Study sampling event to be reconstructed without having to rely on the sampler’s memory. Additional instructions on field documentation procedures can be found in SOP 1 (Field Documentation).

Frontier will record – during each visit – operating conditions (e.g., pressure and flow measurements) as observed during their inspection on the field form provided in Appendix C. They will also record any maintenance activities (e.g., replacement of substrate, unscheduled filter backwashing, etc.) completed during their visit on the field forms.

6.3.2 Sample Identification and Labeling

Samples will be assigned unique sample identification numbers. These numbers are required for tracking the handling, analysis, and reporting status of all samples collected during monitoring. Each sample identification number will identify the sampling location and type of sample. Sample identification numbers will be assigned using several codes as follows.

The first field in the identification number identifies the Site and general time period. For example, samples collected during the Smoky Canyon Mine Pilot Study in July 2014 will all have the prefix “SPS[07][14]”.

The second field in the identification number identifies the location of the sample. For this Pilot Study, this second field will be “LSS-N”.

The third field identifies the sample matrix type and includes a digit describing the intended sample use. The matrix types are defined as:

IN: Influent;

BE: Bioreactor Effluent; and

EF: System Effluent.

The fourth fields are sample use codes and include:

0 – Primary sample;

2 – Field duplicate sample;

3 – Equipment rinsate or QA/QC blank sample; and

4 – Split primary sample.

Note that additional codes may be added as the project proceeds. The additions will be communicated immediately to the field staff, data management team, and project chemist.

The last field is a three-digit number unique to the specific sample. Numbers will begin with 01 and increase consecutively as sampling tasks are implemented. For example:

- SC0814-LSSHS-IN003, is a primary water sample collected from the inlet in August 2014 with the sequential number 3;
- SC0914-LSSHS-EF202, is a field duplicate water sample collected from the treated effluent in September 2014 with the sequential number 2; and
- SC0814-LSSHS-IN403, is a split of the primary water sample collected from the influent in August 2014 with the sequential number 3.

Each sample that is collected in the field will be labeled for future identification. Sample labels will be filled out as completely as possible by a member of the sampling team. All sample labels will be filled out using waterproof ink. At a minimum, each label will contain the following information:

- Sampler's initials;
- Site location;
- Sample identification number;
- Date and time of sample collection;
- Analyses required;
- Sample type; and
- Sampler’s signature/initials.

Site specific samples to be used for the matrix spike/matrix spike duplicates will be identified on the chain-of-custody forms.

6.3.3 Sample Handling and Shipping

After collection, samples will be placed on ice in an insulated cooler, together with packing material to prevent breakage during shipment. A labeled temperature blank may also be included with each cooler shipped, if the laboratory does not possess infrared temperature sensors. Ice placed in the cooler will be double-bagged to prevent leakage of water. The coolers will be taped shut and custody seals attached.

All samples will be transferred or shipped for laboratory receipt and analysis within the holding times specified in Table 3-6.

6.3.4 Sample Custody

After samples have been collected, they will be maintained under strict chain-of-custody (COC) protocols, in accordance with specifications included in the QAPP. The field sampling personnel will complete a COC form for each shipping container (i.e., cooler, ice chest or other container) of samples to be delivered to the laboratory for analysis. The sampler is responsible for initiating and filling out the COC form. The COC for a shipping container will list only those samples in that shipping container. Information contained on the COC form will include the following:

- Project number;
- Date and time of collection;
- Sample identification number;
- Sample matrix;
- Analyses requested;

- Number of containers for each sample;
- Sample preservation;
- Sampler's signature and affiliation;
- Signature of persons relinquishing custody, dates, and times;
- Signature of persons accepting custody, dates, and times;
- Method of shipment;
- Shipping air bill number (if the samples are shipped);
- Condition of samples and cooler temperature upon receipt by laboratory; and
- Any additional instructions to the laboratory.

6.4 Data Quality Indicators

The DQIs for data collected in support of the Pilot Study are accuracy, precision, completeness, representativeness, and comparability. The DQI control limits and acceptance criteria for data collected during the Pilot Study are provided in the QAPP (Formation 2010b). Table 6-1 presents a summary of the project DQIs.

Table 6-1. Laboratory Quality Control Acceptance Criteria

Laboratory Measurement	Method	RL (mg/L)	Data Quality Indicators	
			Accuracy Measures and Control Limits	Precision Measures and Control Limits
Metals/Metalloids/Inorganics				
Aluminum	6010C	0.1	**LCS Recovery:** 80% to 120%	**MS/MSD[1]:** RPD < 20%
Antimony	6020A	0.003		
Arsenic	6020A	0.003		
Barium	6020A	0.001	**MS Recovery[1]:** 75% to 125% **Post Digestion Spike:** 85% to 115%	**Analytical Duplicate:** RPD < 20%
Beryllium	6020A	0.0002		
Boron	6020A	0.05		
Cadmium	6020A	0.0002		**Field Duplicate:** RPD < 20%
Chromium	6020A	0.0015		
Calcium	6010C	0.05	**ICV Recovery:** 90% to 110% (6010C, 6020A) 80% to 120% (7470A)	
Cobalt	6020A	0.001		
Copper	6020A	0.001		
Iron	6010C	0.1	**CCV Recovery:** 90% to 110% (6010C, 6020A) 80% to 120% (7470A)	
Lead	6020A	0.003		
Magnesium	6010C	0.1		
Manganese	6020A	0.001	**Method Blanks:** Less than RL [CRQL]	
Mercury	7470A	0.0002		
Molybdenum	6020A	0.001	**Interference Check Sample:** 80% - 120%	
Nickel	6020A	0.001		

Laboratory Measurement	Method	RL (mg/L)	Data Quality Indicators	
			Accuracy Measures and Control Limits	Precision Measures and Control Limits
Potassium	6010C	0.5	**Interference Check Sample:** 80% - 120%	
Selenium	6020A	0.003		
Silver	6020A	0.0001	**Internal Standard Recovery:** 60% to 125%	
Sodium	6010C	0.5		
Thallium	6020A	0.001		
Uranium	6020A	0.001	**Serial Dilution:** <10% Difference	
Vanadium	6020A	0.0015		
Zinc	6020A	0.005		

6.5 Quality Assurance and Quality Control

The QAPP (Formation 2010b) presents QA/QC policies and procedures developed to ensure that the data collected in the field and analyzed by the laboratory are of appropriate quality to meet project objectives. Certain deviations from the procedures specified by the QAPP are appropriate for data intended to evaluate the performance of the treatment system. These deviations are identified and explained below.

6.5.1 Field Quality Control Samples

The field QC practices will consist of the collection of QC samples, decontamination of field sampling equipment, and adherence to SOPs. These elements are described below.

Equipment rinsates/field blank samples and field duplicate samples will be collected to evaluate the accuracy and reproducibility of the field sampling methods. Data collected in the field may lack reproducibility due to natural variability and/or the field sampling methods. One duplicate and one equipment blank sample for every 20 primary samples will be collected to evaluate the reproducibility of field sampling methods, and assess any influence from sample equipment and sample containers. Field duplicates are useful in documenting combined field and laboratory precision.

<u>Field Duplicates</u>

Field duplicates are collected to measure the combined sampling and analytical variability associated with the sample results. Duplicate samples are usually collected simultaneously with or immediately after the corresponding original samples have been collected, depending on the sample type and medium and consistent with detailed instructions in the relevant SOPs for sample collection. In all cases, the same sampling protocol is used to collect the original sample and the field duplicate sample. The field duplicate is analyzed for the same suite of analytical parameters as the original sample. There are no USEPA criteria for evaluation of field duplicate sample comparability; however, the relative percent difference (RPD) between the original sample and field duplicate can be calculated for each parameter and compared to the project's precision goal. Field duplicate RPDs greater than the project-specified precision goal indicates a high variability associated with the sampling and analysis methods used.

Field duplicates will be collected at a rate of at least 1 per 20 samples, or no less than one per sample event if the number of samples collected in a sampling event is less than 20 samples.

Field Blank Samples

Two types of field blanks will be collected: equipment rinsate blanks and ambient blanks. An equipment rinsate consists of analyte-free reagent-grade water (e.g., ASTM Type II) poured through the sampling equipment, collected in a clean sampling bottle, and preserved as needed. Equipment rinsate samples may be used to demonstrate that sampling devices have been adequately cleaned between uses and provide for representative samples. An ambient blank consists of analyte-free, reagent-grade water poured into an unused, clean sample container at the field sampling location, and preserved as needed. Equipment rinsates and ambient field blanks are analyzed blindly as regular field samples, and they are both analyzed for the same suite of analytical parameters as the associated samples.

Analyses of equipment rinsates and field ambient blanks quantify any artifacts introduced into the sample during collection. Potential sources of bias or cross-contamination include sampling gloves and sampling equipment that may incidentally come into contact with the sample.

Equipment rinsate samples will be collected at rate of 1 per every 10 field samples whenever sampling equipment is reused at multiple sampling locations. Most sampling events associated with the Pilot Study will involve sampling at 2 to 4 locations; therefore, an equipment rinsate blank will be needed approximately every third or fourth sampling event (when sampling equipment is decontaminated and reused).

In the absence of equipment rinsate blanks for water samples that are collected without re-using sampling equipment, field ambient blanks will be collected at a rate of 1 per 20 water samples, or at least one ambient blank per quarter if fewer than 20 samples have been collected during that 3-month period.

Filter Blank Samples

A filter blank sample consists of analyte-free, reagent-grade water pumped through unused, clean tubing and filter into an unused, clean sample container at the field sampling location and preserved as needed. Filter blanks are analyzed blindly as regular field samples, and they are analyzed for the complete list of dissolved target analytes as the associated samples (**Table 3-4** and Table 3-5). Analyses of filter blanks quantify any artifacts introduced into the sample due to the filter tubing and/or filter.

Filter blanks will be collected at a rate of 1 per filter lot.

6.5.2 Laboratory Quality Control Samples

The analytical methods selected will ensure that laboratory analysis is sufficiently sensitive, accurate and precise to meet the objectives of the sampling. The commercial laboratories used will perform the requested analyses in accordance with referenced EPA methods (when available) and will operate under an internal QA Management Plan. Complete raw data packages from each laboratory will be evaluated to assess compliance with DQIs.

The appropriate type and frequency of laboratory QC samples will be dependent on the sample matrix, analytical method, and the laboratory's SOP. Laboratory QC samples will be analyzed in addition to the calibration samples with each QC batch.

The data will be reviewed and evaluated along with the sample results (including field QC sample results) to confirm that the data meet the DQIs. Any data not meeting the DQI requirements identified in this plan will be flagged to identify them to data users and appropriately qualified.

6.5.3 Quality Assessment and Corrective Actions

Field and laboratory procedures will be reviewed by persons having no direct responsibilities for the activities being performed to determine conformance with technical and QA procedures. Corrective actions will be implemented for each nonconformance identified.

The Field Team Leader will be responsible for taking and reporting required corrective action during field activities. A description of deviations from this SAP and any corrective action will be entered in the field notebook. The Laboratory QA Manager will be responsible for taking required corrective actions in response to any problems with data quality during laboratory activities.

6.6 Data Reduction and Review

As an initial step, field measurements will be checked for errors and compared to prior measurements for general accuracy. Anomalous or suspect values will be noted and an explanation provided. Laboratory results will be checked for completeness in order to assure that all the requested analyses were performed along with the correct methodologies and detection limits.

Complete raw data packages from the laboratory will be evaluated to assess compliance with DQIs. Data will also be evaluated to assess whether the measurement performance criteria for accuracy and precision have been achieved. The laboratory will provide a QC summary suitable for this level of review.

Data review will include but will not be limited to:

- Reviewing COC forms and laboratory data sheets to verify that samples were analyzed within specified holding times. Samples which do not satisfy holding time and preservation requirements will be noted and the reliability of the data assessed.
- Reviewing whether the calibration requirements were met.
- Evaluating the accuracy of chemical data using results from laboratory control samples (LCSs) and matrix spike (MS) samples prepared by the laboratory. The laboratory will calculate the percent recoveries for these results. If the recoveries are outside the limits presented in this plan, action will be taken by the laboratory to improve the precision of analytical results.
- Evaluating the precision of the chemical data by comparing original and duplicate sample results. The laboratory will calculate RPD values for the laboratory duplicate samples. If RPD values are outside the limits presented in this plan, action will be taken by the laboratory to improve the precision of the analytical results.
- Reviewing all of the data for potential transcription errors, detection limit discrepancies (laboratory only), data omissions, and suspect or anomalous values. If such errors or deficiencies are found, the laboratory and/or field sampler will be contacted and the appropriate corrective action taken.

The data will be evaluated and compared against the measurement performance criteria, and the data's usability with respect to addressing the Pilot Study objectives will be determined. Adherence to field and laboratory protocols will be reviewed. All field and laboratory data will be summarized in tables, and any trends and relationships evaluated and presented to determine if the data provides strong evidence for a particular action.

6.7 Data Management

The analytical laboratories will report data to the following recipients:

Monty Johnson, J.R. Simplot Company, Project Manager (monty.johnson@simplot.com) – electronic data deliverables

Jonathan Witt, J.R. Simplot Company, Project Technical Manager (jonathan.witt@simplot.com) – electronic data deliverables

Karen Schneider, Formation (kschneider@formationenv.com) – hard copy and electronic data deliverables

Tim Pickett, Frontier Water Systems (timpickett@frontierwater.com) – electronic data deliverables

Mary Kauffman, USFS, (mkauffman@fs.fed.us) – electronic data deliverables.

Deliverables will be sent to the USFS at the same time as they are sent to other recipients.

Paper laboratory reports and associated field documentation will be filed, and the electronic data will be stored in a computer database maintained by Formation. Final entry of the information into the database will not be completed until the data review described above in Section 6.6 is completed, and it is determined that the data reported from the field and laboratory are complete.

7.0 DATA ANALYSIS AND REPORTING

The data collected as part of this Pilot Study will be evaluated to determine if the DQOs are met and to evaluate and report the effectiveness of the treatment system.

7.1 Data Evaluation

Laboratory reports will document sample custody, analytical results and QA/QC, adherence to prescribed protocols, nonconformity events, corrective measures, and/or data deficiencies. The laboratory data will be reviewed and evaluated for accuracy and precision to ensure that the data are of sufficient quality to assess the treatment's performance. The review will confirm that all requested analyses were performed using the procedures specified in the Pilot Study Work Plan. The review will also include evaluation of data quality using results from the laboratory's data quality analyses, including analytical duplicates, matrix spike samples, and control samples or standards. Any deviations from the work plan or concerns regarding data quality will be resolved by working with the laboratory, which may include request for reanalysis of samples.

Field measurements will also be reviewed before those data are reported. The field notes, measurement entries, and any calculations will be subject to a peer review. Errors identified during the review will be corrected by the field staff with documentation of the correction date.

7.2 Data Validation

Data validation will be performed by a third party using the general protocols and processes described in the following documents, as applicable to the method calibration and QC limits specified in the QAPP (Formation 2010b) and to the extent possible when non-CLP methods are used:

- Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (NFG; USEPA, 2004); and
- Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (USPEA, 2009).

Data validation will be performed using a "tiered" approach. One-hundred percent (100%) of the data packages will be evaluated and qualified for all quantitative QC elements (e.g., spike recoveries, method and field blank contamination, duplicate sample %RSD, and instrument stability and performance [e.g., initial and continuing calibration results, instrument tuning and internal standard areas]) using hard-copy summary forms (described above). This validation of

100% of the data is considered Tier 1, and it is equivalent to a "Stage 2B Validation," as defined in the USEPA guidance for labeling externally validated data (USEPA, 2009).[2]

Tier 2 of the project's data validation is equivalent to an "USEPA CLP Level IV" validation and essentially the same as "Stage 4 Validation" (USEPA, 2009).[3] The Tier 2 validation includes all of the Tier 1 elements as well as a complete evaluation of all the raw data. A minimum 10% of the data packages will undergo Tier 2 validation. The data packages selected for Tier 2 validation will be representative of the Pilot Study samples as a whole.

Each laboratory will be required to provide a USEPA Level IV data report for the sample sets targeted by Simplot for Tier 2/Level IV validation. USEPA Level IV data package requirements are included in the QAPP (Formation 2010b).

For the remaining data sets the laboratory will provide the following information in their data reports:

- Field and laboratory sample identification;
- Sample result, method detection limit, and reporting limit, with appropriate units;
- Sample collection and receipt dates;
- Sample preparation and analysis date/time;
- Dilution factor;
- Preparation and analysis batch numbers or identification;
- Sample matrix;
- Analytical method(s) references;
- Percent moisture determination; and
- For solid-matrix samples, identify basis of reporting (i.e., wet-weight or dry-weight basis).

The following additional information will also be provided, as applicable for the reported analytical methods:

- Case narrative;
- Copies of the signed COCs;

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[2] EPA, 2009. Page 6: "A verification and validation based on completeness and compliance checks of sample receipt conditions and BOTH sample-related and instrument-related QC results…"

[3] Ibid, page 7: "A verification and validation based on completeness and compliance checks of sample receipt conditions, both sample-related and instrument-related QC results, recalculation checks, AND the review of actual instrument outputs…"

- Laboratory method/preparation blank;
- Initial calibration verification (ICV), and continuing calibration verification (CCV);
- Initial calibration blanks (ICB), and continuing calibration blank (CCB);
- Interference check sample, if applicable;
- Matrix spike (MS), and when applicable matrix spike duplicate (MSD), sample recovery and, when applicable, MS/MSD relative percent difference (RPD);
- Post-digest spike sample recovery;
- Laboratory duplicate;
- Laboratory control sample (LCS) recovery;
- Inductively coupled plasma mass spectrometry(ICP-MS) serial dilution percent differences;
- Method detection limits (MDLs);
- ICP inter-element correction factors;
- ICP and ICPMS linear ranges;
- Preparation log;
- Analysis run Log;
- ICPMS tunes;
- ICPMS internal standards relative intensity summary;
- Sample log-in sheet; and
- Deliverables inventory sheet.

The tiered data validation approach will be applied for at least one year following startup of the treatment system. After one year of data validation completed as described by this plan, validation findings may be evaluated to determine whether any changes to the tiered approach are warranted. Both increased and decreased levels of effort for ongoing data validation may be considered. Any change in the level of effort associated with ongoing data validation will be identified by Simplot and proposed to the USFS for approval before adoption under this plan.

7.3 Reporting

Unless otherwise specified, Simplot will provide monthly progress reports from the approval of this work plan until decommissioning of the pilot unit.

During the design phase, the reports will describe progress made in design, contractor and equipment procurement and construction, along with an anticipated start-up date, once known.

Weekly email updates on the Pilot Study construction and implementation will be provided to the Forest Service Remedial Project Manager in the form of an email every Friday, or as soon as possible early the next week. The weekly updates will include descriptions of the past week's activities, and the upcoming week's planned activities. Once the system has been running for several weeks and is in steady-state operational mode, the Forest Service and Simplot can determine the need to continue the weekly updates and/or change the frequency of said updates.

During the study implementation, reports will include a description of activities completed in the preceding month and the activities planned for the subsequent six weeks. Field and laboratory data available at the time of each progress report will also be included.

Within 90 days after completion of the Pilot Study, Simplot will prepare a Treatability/Pilot Study Report documenting the findings of the study. Following the Agencies' review of the report, Simplot will address comments and prepare and submit a final Treatability/Pilot Study Report.

8.0 REFERENCES

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Formation, 2014a. Revised Draft Smoky Canyon Mine Remedial Investigation Report. May 2014.

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USEPA, 2004. Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, EPA 540/R-04/004.

APPENDIX A

Calculation of Selenium Load Removal by Treatment

and Effect on Downstream Concentrations

APPENDIX B

Completed Joint Application for Permit

APPENDIX C

Standard Operating Procedures

List of SOPs:

SOP No. 1 Field Documentation

SOP No. 2 Sample Packing, Custody, Shipment

SOP No. 5 Water Quality Sampling

SOP No. 6 Surface Water Discharge Measurement

SOP No. 7 Equipment Decontamination

SOP No. 14 Sediment Sampling for Chemical Analysis

SOP No. 17 Field Measurement for Dissolved Oxygen

APPENDIX D

November 2013 Analytical Results